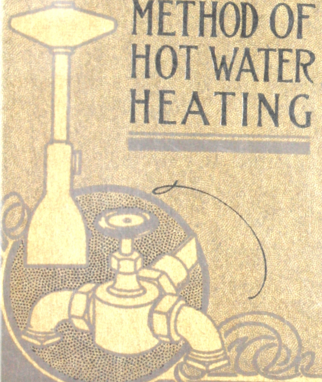
HOW TO PROPERLY DESIGN & INSTALL THE HONEYWELL METHOD OF HOT WATER HEATING



THE OBJECT *of this book is to instruct Architects, Engineers and Heating Contractors how to properly design and install the Honeywell Method of Hot Water Heating.*

It is carefully edited with the idea of placing at their command, as varied and complete information and assistance as possible.

A careful study of this book by all interested in heating will result in producing a heating system of the highest efficiency at lowest cost.

HONEYWELL HEATING SPECIALTY CO.

WABASH, INDIANA

The Honeywell Method

Hot water, as a medium for heating all classes of buildings has so far distanced all other methods that it would seem almost unnecessary, at this time to dwell on its superiority over steam, vapor, vacuum or hot air heating. This booklet will describe the distinct advantages of using the Honeywell Method of piping in connection with Honeywell Heat Generators and having at one's disposal all the virtues to be found in steam, vapor or vacuum systems without any of their disadvantages, and additional attributes to be found in none but the Honeywell Method.

Many heating contractors, by adhering to badly proportioned pipe and valve sizes—unchanged for thirty-five years while all other elements of a heating system progressed—gave some color to the objection often raised against hot water installations: i. e., slowness to heat up.

In an effort to overcome the phantom of their own creation—"friction"—they stuck slavishly to pipe and valve sizes that were not consistent with the advances made in boiler construction and practical research work.

All leading heating engineers have, in the past

few years directed their thoughts towards securing a quick, vigorous circulation of hot water, and to improve on the oversized, slow-moving, irresponsive hot water installations of the old type.

The Honeywell Method in connection with the Honeywell Heat Generator came into immediate and ever-increasing favor because it was the first and is yet the only method of hot water heating based on the application of thoroughly reliable engineering data, and, because the Honeywell Heating Specialty Company, secure in their knowledge that they were "right," had the courage to guarantee their opinions, methods and generators in a way possible only to those "who know."

Architects, heating contractors and house-owners have not been slow to appreciate the merits, the sightliness, economy and high efficiency of our method and there are now installed throughout the United States, Canada—British Empire and Continental Europe—thousands of intelligently sized, properly proportioned and controlled hot water installations testifying to the excellence of the Honeywell Method.

The Honeywell Heat Generator is manufactured in Wabash, Indiana, for United States use—in Montreal, Canada, for Canadian demands—and in Birmingham, England, for requirements of Great Britain, Europe and Asia.

There is no country requiring artificial heat where Honeywell Generators and Method are not known—there is no type of building adapted to hot water heating in which they cannot be successfully applied. Our Method is operating in buildings heated by a battery of boilers connected to 30,000 sq. ft. of radiation and is giving the same splendid service as in more modest plants of 300 sq. ft. It is giving highest satisfaction in plants where mains exceed 400 ft. in length as well as in buildings of 30 ft. over all measurements.

The Honeywell Method is in successful operation in all climes and by its elasticity, wide range of temperatures, ready response to temperature changes and easy control is as well adapted to conditions found in the most northern parts of Canada as those found along the friendly reaches of the lower Mississippi.

Temperature Range.

The Honeywell Method provides a range of temperatures—85° to 240°—not to be found in any other system—steam, vapor, vacuum or uncontrolled hot water.

Our method, operating perfectly at a water temperature of 85° to 100° will cause each radiator to give off that soft, genial warmth so desirable in the mild days of early Fall and late Spring. In the depths of Winter, under the most exacting conditions the ease with which nor-

mal temperatures can be maintained and on occasion high temperatures developed makes the Honeywell Method of greater efficiency than a steam system.

When one considers the "all or nothing" feature of steam—212° to 220°, the short range of vacuum systems—150° to 212°, the small range and sluggishness of old-style, uncontrolled hot water installations, one must see in the Honeywell Method a feature that places it years in advance of any other form of heating.

The Honeywell Heat Generator produces "*safely and automatically*," by the action of mercury, a pressure ranging from 0 to 10 pounds and seals the entire system from the atmosphere until 10 pounds are produced.

The pressure will vary strictly as the water temperatures vary in keeping with heat requirements of the building. With a pressure of 10 pounds applied to the water and the application of some elementary instructions, radiator tappings are used 60 to 75 per cent. below sizes necessary in the old-style, uncontrolled systems.

Our object in establishing size of pipes and valves, is to eliminate as much water as possible from the system and by so doing, increase boiler economy and efficiency.

We quote from an eminent authority: "Water at rest is a poor absorber of heat, but when in motion, it has a large capacity for carrying heat;

hence a water heating apparatus containing a small quantity of water, circulating rapidly, is more economical of fuel than is an apparatus which contains a large quantity of water and has a sluggish circulation, because in the high velocity apparatus, the heat from the fuel is more rapidly taken up and a higher percentage of fuel power is thus available."

A smaller body of water will require less fuel to heat it through a given number of temperature degrees; less power will be required to move the water through boiler and radiators, and a great saving will be effected in heat transmission.

This, anyone, who has compared the Honeywell Method of piping with the old style, will admit just as surely as he will admit that a large radiator will give off more heat units than a small one, both operating at the same temperature difference.

The Honeywell Method of piping with the action of our Generator, causes the water to circulate through the system much faster than possible in the old style, uncontrolled installations.

Circulation.

Because of this greatly increased velocity the water is changed much oftener over the heated plates of the boiler, thus absorbing, in a given period of time, thousands more of the B. T. U.

from the fire and preventing the loss of countless thousands through the chimney.

Water is a very poor conductor of heat; the molecules of water do not readily impart heat one to another but require a continual circulation and mixture. It is, however, an excellent conveyor, and readily takes up heat if passed in small bodies over a heated surface and gives off heat when passed in like bulk over cooling surfaces.

All practical authorities agree that in hot water installations a slight pressure increases the velocity and efficiency by a partial emulsion (at any increasing temperature) of the water in the flow pipe.

When water passes over heated surfaces there are formed innumerable globules of steam. Scientific experiments show us that under pressure these globules are compressed to a greater density and that they break away from heating surfaces with greater rapidity than where there is no pressure applied. These globules, under pressure, as in Honeywell Method, live longer in the flow pipes, emulse the water and make it lighter. The water passing through the radiators, gives off heat, becomes devoid of globules and by greater weight, establishes an increased circulation.

If we consider that the heating value of a

pound of coal is not elastic we will see the reason for accelerating circulation by a slight pressure and reductions of water bulk.

Heating Value of Coal.

The general average heat emission value of anthracite coal is 12,000 B. T. U. per pound. Of this, fully 30 per cent. is used to create draft, or is wasted in ash, clinker, slate or other incombustible matter. This leaves 8,400 B. T. U. per pound of coal available for transference to the radiation.

As the rate of transmission between fuel and water increases in proportion to temperature difference—it is obvious that a high velocity, by supplying ever changing water and increasing temperature difference—insures a high rate of transmission.

By improper conditions of *installation*, poor chimney draft or false ideas about stack temperature, the rate of emission can be reduced as low as 4,000 B. T. U.

If, through an overload of water or any condition causing sluggishness, the water does not come into quickly repeated contact with heated surfaces of the boiler, a greater number of B. T. U. will be wasted up the chimney; let us remember that in a given time with a given draft the pound or charge of fuel will burn out whether the water in the plant has impinged a satisfactory proportion of B. T. U. or not.

The Honeywell Method and Heat Generator, quickening the circulation by a slight pressure, by reducing water overload, and by intelligent attention to piping detail prevent this loss and make it possible for fast-moving water to absorb the full 8,400 available B. T. U. per pound of coal.

Radiation Amounts.

Because of greatly increased rate of transmission of heat units from fire and reduced loss in transmission through our establishment of pipe sizes—a general higher average temperature is maintained in the radiators; for this reason radiator surfaces may be somewhat reduced under conditions as outlined in our rules, pages 24 to 28.

We strongly deprecate high water temperatures at the boiler, made necessary by unreasoning reductions in radiator surfaces. We recommend radiator amounts that will give satisfactory results at normal temperatures, as per boiler manufacturers' basis of guarantee. However, during extremely cold snaps the ability to send the water temperature up to 240° (as high as ten pounds steam temperature) without the annoyance of boiling is an advantage that cannot be overestimated and makes the Honeywell Method of as great efficiency as an ordinary steam installation.

The Honeywell Heat Generator
How It Operates

A careful study of Figures 1, 2 and 3, and a perusal of our description will clearly explain the operation of the Generator.

When the water in the plant is cold, the mercury, 13, Fig. 1, will all lie at the bottom of the mercury pot, 7, about 1 inch in depth, and all other parts of the Generator will be immersed in water.

When the water begins to expand it flows into the Generator at 6 and presses, 9 on the mercury, 13, Fig. 1. The expansion of the water thus forces the mercury down into the mercury pot, 7, and up through the circulating tube, 4, and stand pipe, 5, Fig. 2. As the water continues to expand the mercury will rise in the circulating tube, 4, and stand pipe, 5, and will lower to a corresponding extent in the mercury pot, 7, Fig. 2, until it lies level with the top of the circulating tube inlet, 14, Fig. 3. At this time the mercury is level with the top of the circulating tube, 4, and stand pipe, 5, Fig. 3.

The water having forced the mercury down slightly below the top of inlet 14, Fig. 3, will pass over the mercury, 13, Fig. 3, into the circulating tube 4; the water being over thirteen times

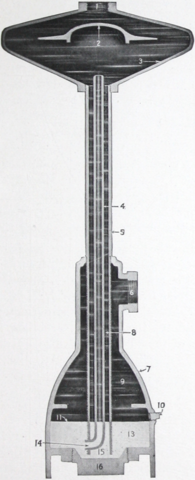


Fig. I
Illustrating position of mercury and water when Generator is producing NO pressure.

lighter than the mercury, will pass through circulating tube, 4, constantly carrying a quantity of mercury with it. When the water and mercury reach the top of the circulating tube, 4, the water will pass up and around the deflector, 2, Fig. 3, and out to opening, 1, to the expansion tank. The mercury which is driven upward with the water in the circulating tube, 4, will not return through this same tube, but through space 8, in the stand pipe, 5, into space 15. From space 15, it passes into mercury chamber of pot 7, thus raising the mercury level in the mercury chamber, and operating in a manner similar to a balanced valve, to regulate the passage of water through the circulating tube, 4.

From the above description it is apparent that a positive circulation of the mercury upward through the circulating tube, 4, and downward through the stand pipe, 5, Fig. 3, is attained under all normal working conditions, thus positively retaining the mercury within the circulating tubes of the Generator.

It is this feature that distinguishes the Honeywell Generator from all competitive devices, and puts it in a class by itself. It is the only device providing a positive, interior circulation, making it possible to produce and maintain a pressure of 10 pounds and permitting all water of expansion in excess of 10 pounds to pass readily and freely to the expansion tank.

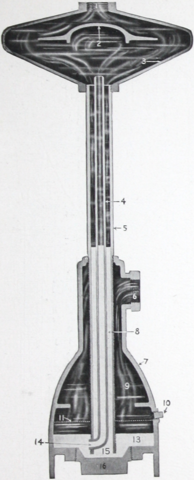


Fig. II
Illustrating position of mercury and water when Generator is producing partial pressure.

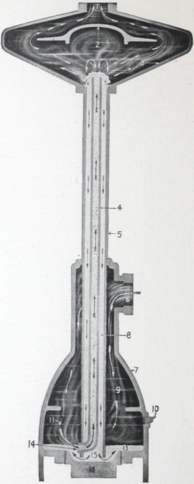
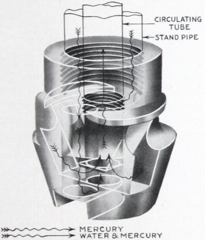


Fig. III

Illustrating position and action of mercury and water, when Generator is in complete operation, producing 10 pounds pressure.

When the water throughout the system cools and contracts, the exact reverse of the above operation takes place and the mercury will gradually lower in the circulating tube, 4, and stand pipe, 5, and rise to a corresponding extent in the mercury chamber of pot, 7, Fig. 2. If the water continues to cool, this action will continue until the mercury will all lie in the mercury chamber, to a depth of about 1 inch, 11, Fig. 1.



Illustrating construction of shoe and plug.
X-Ray view of plug and shoe.

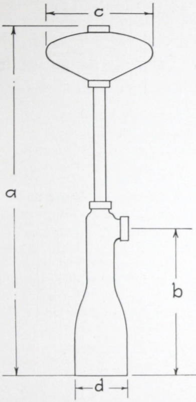
A pressure of half a pound at 1, *causes the water to flow* from the expansion tank downward through the stand pipe, outward through space 15, thus upward through the mercury, 13, Fig. 1, and out through 6, into the system.

When filling the system from city service, the rapid flow of water at high pressure to the Generator, will lift the mercury and force it all upward and into the separating chamber, 3, where the deflector, 2, will arrest the mercury, and the full flow of water will pass to the tank unobstructed through the Generator; the moment the valve in the city service pipe is closed, the mercury will drop into the bottom of the mercury pot, 7, Fig. 1, and will be ready for operation again.

Draining the Generator

Generators should be connected to the piping with unions located as close to them as possible. When the plant is to be left without fire in cold weather, it should be drained, after which the Generator must be disconnected; this will require but a few minutes time. By holding the Generator in a horizontal position and rocking it back and forth, the water and mercury can be poured out through the large tapping on the side of the lower casting. Care should be taken that no mercury is lost.

After the Generatcr is empty the mercury should be poured back into it through any of the open tappings and it can then be set aside until the plant is to be used, when it will require but a few minutes time to reconnect it to the piping.



Generator	a	b	c	d
No-1	28½"	12½"	8½"	4½"
No-2	29¼"	12½"	9"	5"
No-3	30½"	12"	12½"	6"
No-4	30½"	12"	12½"	7"

Skeleton sketch showing roughing in measurements of different sized Generators.

How to Correctly Design and Install The Honeywell Method

The Chimney.

The question of the chimney is so important that it should engage the serious attention of the architect, heating contractor and house owner. Each in his own sphere, should see that a chimney is provided of such area and height as will insure the best possible combustion in the fire pot of the boiler.

A round chimney is the best form, as smoke and gases rise in a spiral column and find less resistance in a round chimney than in other types.

Oval, square and rectangular chimneys are efficient in the order named.

Air Required.

There is sufficient oxygen in 300 cubic feet of air for the proper combustion of a pound of coal. With an insufficient supply of air, the coal decomposes, gases (two-thirds complete value of coal) pass up chimney unconsumed, coal is wasted, boiler rendered inefficient, installation condemned.

"Each atom of carbon requires for its perfect combustion, two atoms of oxygen. When this

union is effected it burns to carbon dioxide (CO_2) and yields per pound 14,500 B. T. U.

If, however, through insufficient air supply there is but one atom of oxygen to one of carbon, the result is carbon monoxide (CO), yielding 4,500 B. T. U., or less than one-third the heat given off where combustion is perfect."

Poor combustion results in enormous coal consumption with little heating effect.

The falling off in boiler efficiency through poor draft is frequently as 1 is to 3.

All air for proper combustion must pass under the grates and through the coal.

Proper conditions cannot exist when an attempt is made to keep stack temperatures as low as water temperatures. With a low stack temperature the difference in weight between the columns of air (inside the chimney flue and outside) is not great enough to induce through the bed of fuel, the column of air necessary for proper combustion.

It too often happens that intensity of draft is mistaken for proper volume. Care should be exercised to distinguish between the two and to provide sufficient area to supply enough air at proper intensity of draft.

To aid the heating contractor in determining draft efficiency, we quote from standard authorities the following table:

Siphon Pressure Draft Gauge.

Height Water in inches	Pressure in lbs. per sq. ft.	Velocity ft. per sec.	Velocity ft. per min.	Height Water in inches	Pressure in lbs. per sq. ft.	Velocity ft. per sec.	Velocity ft. per min.
.1	.521	15.05	903	1.1	5.731	49.9	2994
.2	1.042	21.3	1278	1.2	6.252	52.1	3126
.3	1.563	26.06	1564	1.3	6.773	54.2	3252
.4	2.084	30.1	1806	1.4	7.294	56.3	3378
.5	2.605	33.6	2016	1.5	7.815	58.2	3492
.6	3.126	36.8	2208	1.6	8.336	60.2	3612
.7	3.647	39.8	2388	1.7	8.857	62.0	3720
.8	4.168	42.5	2550	1.8	9.378	63.8	3828
.9	4.689	45.1	2706	1.9	9.899	65.6	3936
1.0	5.210	47.5	2850	2.0	10.420	67.3	4038

Heating contractors and house owners often claim they have entirely adequate draft because the chimney roars, or as they express it, "would pull your hat off;" they forget that if a 2″ pipe were connected to their boiler as a chimney flue, it would still roar, but by no means could it supply a proper volume of air.

See that flue extends full size from smoke pipe opening to a point a few feet higher than the top of the house or apex of the roof.

It is important that the house boiler be attached to a chimney with only one opening.

Any other openings, whether for draft or ventilating purposes, must be tightly closed up.

There should be no offsets, sharp angles or

reductions through chimney's entire course, as the effectiveness of a chimney can only be judged by its smallest area.

In buildings where there are two or more flues in one chimney, there should be a dividing wall from top to bottom, so as to make each flue independent of the other through its entire length.

From its supreme importance it is well to make a draft as perfect as possible—if later on considered too strong—it is easier and cheaper to check by proper arrangement of dampers than it is to bolster up by changes to flue.

See that the smoke pipe does not project into chimney so as to lessen flue area at this most important point.

In practice a square or rectangular flue is no more extensive than the size of circle that can be inscribed in it.

The selection of proper size and design of chimney should rest with architect and heating contractor, as they will be fully acquainted with local conditions pertaining to and perhaps qualifying each installation.

The following table from reliable authorities may be used as a guide:

	Sq. Ft. Rad.					
From	300 to	600	8 in. r'nd	or	8x 8 in.–20 ft.	high
From	600 to	1000	10 in. r'nd	or	10x10 in.–30 ft.	high
From	1000 to	1500	12 in. r'nd	or	12x12 in.–40 ft.	high
From	1500 to	2000	14 in. r'nd	or	14x14 in.–45 ft.	high
From	2000 to	3000	16 in. r'nd	or	16x16 in.–50 ft.	high
From	3000 to	4000	18 in. r'nd	or	18x18 in.–50 ft.	high
From	4000 to	6000	20 in. r'nd	or	20x20 in.–60 ft.	high
From	6000 to	10000	24 in. r'nd	or	24x24 in.–60 ft.	high
From	10000 to	15000	30 in. r'nd	or	30x30 in.–70 ft.	bigh

Construction of Building.

The heating contractor should make a thorough examination of construction or proposed construction of the building he proposes to heat. This applies equally well to all classes of buildings.

In residence work, particularly of veneered construction, special care should be exercised to ascertain whether the construction is such as will permit a circulation of air up and down between the studding and crosswise through the ceilings. It has been found almost impossible to heat buildings so constructed, as the heat losses are excessive. New buildings, as well as old, very often, have very loosely fitting doors and windows, due to poor construction and shrinkage. By way of illustration, let us consider a ten-room house with three outside doors, each 3x7; eighteen windows each 2 ft. 6 in. x 6 ft. in size. Assuming a clearance of ⅛ inch all around each of the doors and a clearance of 1/16 inch around each of the windows, plus a clearance of 1/16x2 ft. 6 in. where the sash joins we find a total area of 353 sq. in. equal to a pipe of 21 in. in diameter, through which the cold, outside air is pouring into the building.

These figures are not exaggerated and illustrate why, in many cases, it is impossible to heat a building with the amounts of radiation or boiler capacity quite adequate to heat a properly constructed building of like dimension.

A careful study of the rate of heat transmission through different building materials (as per tables, pages 31–32) will be of immense value in helping the architect or heating contractor to figure the amount of radiation required.

Proportioning Radiation.

Because of the widely varying conditions surrounding heating installations, it is impossible to give any one rule that can, without modifications or enlargements, be accepted for all classes of buildings and in all localities.

The variation in heat loss through different materials is extremely wide—some materials losing at a like temperature difference twice as much as others. To illustrate the loss of heat units through an 8-inch wall is 66 per cent. more than through a 16-inch wall.

There are many methods of figuring radiation; several, with much to recommend them—others little better than a rule of thumb—some of no value except under rigidly fixed conditions and others leaving so much to the individual judgment as to be nothing better than a guess unless used by a thoroughly trained, honest heating contractor.

We publish, pages 24 to 28, several rules for different temperature differences that we can recommend as being (by factors chosen) correct for Honeywell Method.

They are based on the assumption that walls are 12-inch solid brick or other *equivalent* construction.

They assume that there is no undue loss through badly fitting doors and windows or through improper or skimped construction of any kind, and that care has been taken to select the proper temperature difference.

When proper conditions do not obtain it becomes necessary to select from our table of heat transmission constants, a factor in keeping with local conditions and to provide for all extraordinary losses due to poor construction or exceptional exposure.

These rules will be found variable enough to suit any temperature difference between 20 degrees below zero outside to 70 degrees inside or a temperature range of 90 degrees temperature difference.

Rule No. 1.

For one change of air per hour, when the outside temperature is 20 degrees above zero, to maintain an inside temperature of 70 degrees with a boiler temperature of 180 degrees:

Multiply the cubic contents by............. 1
Multiply the square feet of glass (counting outside doors as glass) by................50
Multiply the square feet of exposed wall (net) by...............................17

Add the results thus obtained and divide by 160.

The result will be the number of square feet of direct radiation required to heat the room.

Rule No. 2.

For one change of air per hour when the outside temperature is 10 degrees above zero, to maintain an inside temperature of 70 degrees with a boiler temperature of 180 degrees:

Multiply the cubic contents by 1.2

Multiply the square feet of glass (counting outside doors as glass) by 65

Multiply the square feet of exposed wall (net) by 20

Add the results thus obtained and divide by 160.

The result will be the number of square feet of direct radiation required to heat the room.

Rule No. 3.

For one change of air per hour, when the outside temperature is zero, to maintain an inside temperature of 70 degrees, with a boiler temperature of 180 degrees:

Multiply the cubic contents by 1.4

Multiply the square feet of glass (counting outside doors as glass) by 75

Multiply the square feet of exposed wall (net) by 25

Add the results thus obtained and divide by 160.

The result will be the number of square feet of direct radiation required to heat the room.

Rule No. 4.

For one change of air per hour, when the outside temperature is 10 degrees below zero, to maintain an inside temperature of 70 degrees, with a boiler temperature of 180 degrees:

Multiply the cubic contents by 1.6

Multiply the square feet of glass (counting outside doors as glass) by 85

Multiply the square feet of exposed wall (net) by 27

Add the results thus obtained and divide by 160.

The result will be the square feet of direct radiation required to heat the room.

Rule No. 5.

For one change of air per hour, when the outside temperature is 20 degrees below zero, to maintain an inside temperature of 70 degrees with a boiler temperature of 180 degrees:

Multiply the cubic contents by 1.8

Multiply the square feet of glass (counting outside doors as glass) by 95

Multiply the square feet of exposed wall (net) by 30

Add the results thus obtained and divide by 160.

The result will be the square feet of direct radiation required to heat the room.

Example.

Consider a room 14x15 exposed on two sides and having a 10-foot ceiling. The room has 60 square feet of glass and 230 (net) square feet of exposed wall. To find the correct amount of radiator surface to maintain 70 degrees inside when the outside temperature is at zero, use Rule No. 3, as follows:

Cubic contents	2100x 1.4	2940
Glass square feet	60x75	4500
Wall square feet	230x25	5750
		13190

13190 divided by 160.........82 square feet of direct radiation.

To figure the same room for a maximum outside temperature of 20 degrees above zero, use Rule No. 1; if for 20 degrees below zero, use Rule No. 5, etc.

If provision is to be made for two changes of air per hour, double the factor used in multiplying cubic contents; if more changes are to be provided for, increase factor in like ratio. Thus: taking our room 14x15x10 and figuring by Rule No. 3 for two changes of air per hour, the cubic contents would be multiplied by 2.8.

$$2100 \times 2.8 = 5880.$$

For four changes of air per hour factor would be 5.6.

$$2100 \times 5.6 = 11760.$$

We dwell on this subject on account of its great importance.

In a room fitted with loose windows and exposed to a strong wind, the air will change three or four times per hour, and if radiation has been figured for one change per hour, the room will be cold and a continual source of annoyance and dissatisfaction.

Figuring our same room for like conditions, by methods somewhat in vogue, we get an answer as low as 52 square feet or a difference between our calculation and theirs amounting to 38 per cent. This cannot be sufficient and needless to say we do not countenance such, or a like selection.

It is advisable to add 10 to 15 per cent. for northern and western exposures, and in cases where building is heated only in day time or at irregular periods.

When computing radiation for buildings three or more stories high, the intermediate stories will have both floors and ceilings warmed and radiation may safely be figured 10 to 15 per cent. lower than for first or top floor rooms.

If double or storm windows are used, the multiplier for glass should be reduced 50 per cent.

In top floor rooms, roof should be considered as cooling surface and so figured; too often roof is neglected and it is almost impossible to heat such top floor rooms.

The loss in B. T. U. through a ceiling close to roof or where no provision has been made to provide a space for still air is 150 per cent. greater than through ceiling with large and proper air space.

When complaint is made that top floor or attic cannot be heated, the solution is easily found by considering type of roof.

Proper attention to local requirements resulting, perhaps, in a little extra radiator surface, will not cost the heating contractor any serious increase in initial outlay, and will insure a more economical and better working job.

If indirect radiation is used 50 per cent. at least, should be added to radiation amounts required for direct heating and provision should be made in boiler for increased load.

B. T. U. Required for Heating Air.

The following table taken from F. Schumann's Manual of Heating and Ventilation indicates in British Thermal Units the quantity of heat required to raise one cubic foot of air through any temperature difference. A careful consideration of factors applying to temperature difference to

be provided for in house heating, will determine the basis of an eminently dependable rule of radiation computation.

External Temp.	Inside Temperature					
	40°	50°	60°	70°	80°	90°
-20	1.290	1.505	1.720	1.935	2.150	2.365
-10	1.051	1.262	1.473	1.684	1.892	2.102
0	0.822	1.028	1.234	1.439	1.645	1.851
10	0.604	0.805	1.007	1.208	1.409	1.611
20	0.393	0.590	0.787	0.984	1.181	1.378
30	0.192	0.385	0.578	0.770	0.963	1.155
40	0.000	0.188	0.376	0.564	0.752	0.940
50	0.000	0.000	0.184	0.365	0.551	0.735
60	0.000	0.000	0.000	0.179	0.359	0.538
70	0.000	0.000	0.000	0.000	0.175	0.350

Constants for Heat Transmission.

When the temperatures on opposite sides of any surface are unequal, the heat will flow through the material from the warmer to the cooler side. This is called heat transmission.

The following constants will supplement the preceding table and indicate the B. T. U. lost per square foot per hour per degree temperature difference through the different materials:

8-inch brick wall........................ .46
12-inch brick wall........................ .33
16-inch brick wall........................ .27
20-inch brick wall........................ .23
8-inch cement or concrete wall........... .70
12-inch cement or concrete wall .... .50

16-inch cement or concrete wall	.41
8-inch stone wall	.52
12-inch stone wall	.44
16-inch stone wall	.36
Single glass	1.090
Double glass	.545
Frame construction, good	.32
Frame construction, poor	.64
Ceiling close to roof, according to construction	.32 to .64
Ceiling with good, tight air space	.128

Examples.

One square foot of 12-inch brick wall at 70 degrees temperature difference:

.33x70 equals 23 B. T. U.

One square foot of single glass at 70 degrees temperature difference:

1.090x70 equals 76 B. T. U. lost per hour.

One square foot poor frame construction at 70 degrees temperature difference:

.64x70 equals 45 B. T. U.

One square foot of ceiling close to roof:

.32x70 equals 22 B. T. U.

One square foot of ceiling with good, tight air space:

.128x70 equals 9 B. T. U.

Co-Efficient of Heat Emission.

This term is applied to quantity of heat given off by one square foot of radiation per hour, per

one degree temperature difference between water in the radiator and the surrounding air. This quantity is sufficiently constant to warrant taking figure 1.65 B. T. U. as multiplier.

Example.

Radiator 160 degrees—air 70 degrees—difference, 90 degrees:

$90° \times 1.65$ B. T. U.$=148.50$ B. T. U., emitted per square foot under conditions described.

The number of B. T. U. required to heat the air, plus quantity lost through different materials used in construction, divided by the emission of one square foot of radiation gives the quantity of radiation necessary.

In calculations for Honeywell Method a higher emission factor is chosen as divisor (160°) with a proportionate reduction in quotient.

We cannot too strongly urge a careful, intelligent interpretation of the foregoing tables and data.

Table of Equivalent Temperatures.

Prof. Carpenter gives the following table for determining the efficiency of a heating apparatus under any specified condition. It is generally accepted as the standard test. For water, the radiator temperature is assumed in all cases to be at an average of 160° Fahr.

Temperature Outside Air	Room Should be Raised to	Temperature Outside Air	Room Should be Raised to
-10°	64.7	50°	98.7
0°	70.0	60°	104.7
10°	75.1	70°	110.5
20°	81.0	80°	117.1
30°	86.5	90°	123.5
40°	93	100°	130.3

To determine by a test of the apparatus when weather is 30°, whether a guarantee to heat to 70° in zero weather is fulfilled, operate the apparatus as though for zero weather and note the average temperature of the room; if the room has a temperature equal to 86° (at 30° outside), it would have a temperature of 70° in zero weather, all other conditions, such as wind, position of windows, etc., etc., being the same as on the day of the test.

Location of Radiators.

Radiators should, when possible, be located against outside walls; it has been found good practice to locate them under windows so as to offset the displacement of air caused by the considerable loss of heat units through glass.

They should be set a sufficient distance from wall to permit the freest possible circulation of air around them. *There should be through a radiator the same proportion of "pitch" to air vent end as in the mains.*

Each radiator should be equipped with an air valve placed so as to insure the clearance of all the air from all the loops.

Care should be taken to see that water stands at all times above the top connecting ports, otherwise there can be no proper circulation and the water in the loops will be heated only by contact with water entering bottom port.

Capacity of Boiler.

The question of boiler capacity is one that deserves the most serious consideration. There are so many excellent types of boilers now on the market that with a little care the Architect or Heating Contractor should have no difficulty in selecting one suitable to his purposes.

It is, of course, of first importance that boiler be of ample power—that there should be a comfortable reserve force.

A boiler built with thin waterways, large flue areas and deep fire pot can usually be depended on for satisfactory results. Small and medium-sized round boilers should have a depth of fire pot approximately equal to the diameter of the grate. It is generally good practice to use a horizontal sectional boiler for jobs of more than one thousand square feet.

The Honeywell Method asks or makes no concessions in boiler capacity. The size of boiler that would be needed to give satisfaction in uncontrolled, large pipe jobs will give better results

and afford a higher degree of satisfaction when used in connection with the Honeywell Method.

The tendency of all improvements in house heating boilers, during the past fifteen years, has been in keeping with the thought and policy of the Honeywell Method.

A boiler should be chosen with a fuel capacity sufficient to carry full load in most severe weather, for a period of six to eight hours.

As extreme conditions prevail for only a small part of winter, the firing period in mild weather will be lengthened and fuel consumption reduced, nevertheless, it is well that a house heating boiler should have reserve capacity enough to do its work in coldest weather without driving at continued extreme temperatures and unreasonably frequent firing periods.

Such a reserve will prevent the quick falling off in house temperatures that goes with a "skimped" boiler and will provide against a cold house in the morning. The difference in cost between a boiler that is "about" big enough and one that "is" big enough will be found trifling.

The difference in results, in satisfaction, in saving, in comfort, will be so great that no house owner would hesitate a moment between the two sizes were they intelligently explained to him.

From careful consideration of all types and makes we recommend that a boiler be chosen

with a rating *at least 50 per cent. in excess of net load of direct radiation.* Unfavorable conditions, such as wet or open cellar, badly constructed walls or a desire for unusually infrequent firing periods, etc., etc., often make it desirable to select a boiler with a greater margin. The Architect, Heating Contractor and house owner should carefully consider all conditions in making selection.

Water for Domestic Purposes.

We strongly recommend that a separate water heater be used to heat water for domestic purposes. Under best conditions of installation a coil in fire pot is not to be recommended—under some conditions it is absolutely harmful, as it takes away from the boiler some of its most effective grate and heating surface.

When a pipe coil is introduced into the fire pot additional capacity should be figured in determining size of boiler, viz.: 2½ sq. ft. of direct radiation according to capacity of tank to which coil is connected, or expressed otherwise, if 30-gallon tank is used it should be figured as a continual load of 75 sq. ft. of direct radiation.

Fuel Capacities.

Our recommendations apply to boilers burning anthracite coal, as this fuel has a more uniform heat emission value than others.

Hard coal weighs approximately fifty pounds

per cubic foot—while soft coal weighs approximately forty.

When soft coal of same heat emission value as hard coal is used, a boiler with 25 per cent. greater fuel holding capacity is needed to hold an equal weight of fuel.

Coal of lower heating value requires selection of boiler with larger fuel holding capacity.

Where to Locate Boiler.

In residences and small buildings it is usually best to locate the boiler at one end or in corner of the building (if the location of the chimney will permit), as such location will allow of a better piping system and better circulation and will somewhat reduce the cost of installation. (See illustration, opposite page 46.)

In many large buildings it is advisable to locate the boiler at one side in center of basement, thus eliminating excessively long mains.

The Smoke Pipe and Dampers.

Always connect the boiler to the chimney with a smoke pipe of the same size as the outlet on the boiler and make it as straight and as short as possible. A tight damper should be placed in the smoke pipe near the boiler. When dampers are to be thermostatically controlled, it is essential that a balanced check damper of area equal to the smoke pipe be used, and it should be located between the tight damper and the chimney.

Size of Valves.

The valve sizes used in Honeywell Method were determined by exhaustive tests under all conditions of service; as these sizes are the basis used in calculating proper main area, we recommend a careful and intelligent study of sizes and relative position of valves on the piping system. The conclusions we reached as a result of our early tests have been splendidly justified by the universal application of our sizes.

The Honeywell Heating Specialty Company was the first to break away from the ironclad tapping list (unchanged for thirty-five years) that, through its inflexibility was the cause of so much bad fitting and poorly reasoned piping plans. This Company was the first to formulate a reasoned valve size schedule that could be guaranteed to give definite results under definite conditions.

A consideration of tables showing capacities in B. T. U. of different-sized mains and risers at different heights from center of boiler to center of radiating surfaces will indicate the basis of our reasoning on this subject.

These tables are to be found in works of leading authorities on hot water heating, in Europe and America, have been embodied in catalogues of leading manufacturers and have been abundantly justified by practical experience.

The scope of this booklet allows us to give the following list of radiator tappings to serve as a reliable guide.

First Floor.

Up to 30 square feet	½ inch
From 30 to 60 square feet	¾ inch
From 60 to 100 square feet	1 inch

Second Floor.

Up to 40 square feet	½ inch
From 40 to 100 square feet	¾ inch
Over 100 square feet	1 inch

Third Floor.

Up to 50 square feet	½ inch
From 50 to 125 square feet	¾ inch
Over 125 square feet	1 inch

The valve on the radiator at the end of the main should, generally, be made one size larger than the list indicates. In many instances a study of local conditions will allow the Heating Contractor to vary these radiator tappings somewhat. We recommend, however, a close adherence to this list, especially with beginners.

Piping System.

The importance of a correct piping layout is sufficient to warrant the most careful thought and calculation. No installation should be attempted without first having planned the sizes and disposition of piping and valves.

A first floor plan of the building should be drawn and accurately scaled one-quarter inch to the foot. The first floor radiators should be properly located and the footage indicated on each; the location of the second (or higher) floor radiators should then be decided on and location of the risers against or inside the walls definitely indicated on the plan. Now mark in the risers, giving them a slant of 45 degrees that they may be distinguished from other pipes (see illustration, opposite page 46), and at the top of each pair of risers indicate plainly the footage of the radiators these risers are to supply.

Taking the foregoing tapping list as a guide, the next step is to indicate clearly at each radiator the size of the valve to be used.

Complete data for laying in the piping system is now shown on the plan, and the piping should be pencilled in.

If the general outline of the building is square or oblong and the boiler has been located at one end or in a corner, two mains are usually enough. In long, narrow buildings, where most of the radiation is located at one exposed side, one main is often sufficient. The mains should be extended as directly as possible and end in the largest practicable first floor radiator. *Never end mains in risers which extend to a second (or higher) floor.*

Try to balance the piping system by having

each main supply as nearly as convenient, equal amounts of radiation; this can, however, only be a recommendation and good judgment must largely govern.

Pencil in the branches which connect the radiators and risers to the mains. When this is completed the piping plan is ready to have the pipe sizes marked on it.

Sizes of Mains.

This question is one much debated by Heating Engineers for many years; widely varying opinions resulted in adoption of widely varied piping sizes.

It was assumed and is yet by some few that a main of certain size could properly feed a certain footage of radiation irrespective of distribution and location of radiators. This is so clearly erroneous as to need little attention. Others persisted in mistaking volume for velocity and did not appreciate that a square foot of radiation could not be made to give off at a given temperature difference more than a fixed number of B. T. U. per hour, regardless of size of connection.

Some had the idea that increasing the valve size "somehow" increased the rate of emission through a square foot of radiation.

Our rule—based on valve areas—they, in turn, based on rate of transmission at different heights through one square foot of radiation, is absolutely dependable.

RULE—*The area of the main must equal or exceed slightly the combined area of the valves it is to supply.* Use main of nearest commercial pipe size larger than total valve area.

This rule has never gone and can not go astray; its application in connection with Honeywell Valve sizes will result in a smaller and more intelligent load of piping than any other method of calculation.

A careful study of the piping plan shown opposite page 46 will illustrate the application of this rule.

Area of Pipes and Valves.

½ inch	.20	sq. inch
¾ "	.44	" "
1 "	.78	" "
1¼ "	1.22	" "
1½ "	1.76	" "
2 "	3.14	" "
2½ "	4.90	" "
3 "	7.06	" "
3½ "	9.62	" "
4 "	12.56	" "
4½ "	15.90	" "
5 "	19.63	" "
6 "	28.27	" "
7 "	38.48	" "
8 "	50.26	" "
9 "	63.61	" "
10 "	78.54	" "

Main No. 1 is 40 feet long and supplies nine radiators, distributed as follows: four on first floor with a total footage of 296 square feet; four on second floor with footage of 292 square feet and one on third floor of 10 square feet. Total footage of radiation amounts to 598 square feet.

The main starts from boiler 2½ inches; first radiator on first floor, 90 square feet, is fed through a 1-inch valve; branch to it is taken off main through an "A" connection. The next two radiators on second floor are fed through a ¾-inch and a ½-inch valve, respectively. The branch and riser to them are 1 inch and branch is tapped into main by "D" connection. These three radiators return their water to boiler through a separate return pipe, starting back from first floor radiator 1¼-inch and increasing where two upper floor radiators enter to 1½-inch and so running to a separate opening in boiler. This point is very important and particular attention is called to it.

The fourth radiator on main (39 square feet on first floor) is fed through a ¾-inch valve. The branch is let into main by a "B" connection. This illustrates our unvarying method of making a reduction in the main. At "B" the main reduces from 2½ inch to 2 inch and the air is positively vented at the point through "B" connection leading to a nearby first floor radiator.

The next connection "D," leads to two ra-

diators; one, 65 square feet on second floor, the other, 10 square feet on third floor.

Branch and riser run 1 inch to tee leading to 65 square foot radiator. Top of tee is used for middle floor radiator with ¾-inch valve. Side of tee is reduced to ¾-inch and riser to top floor extends to 10 square foot radiator, which is fed through a ½-inch valve. This arrangement will be perfectly understood by a study of "E" connection, page 57.

Under no circumstances should top opening of tee be used for top floor radiator.

The seventh radiator on main (third on first floor) contains 39 square feet and is fed by a ¾-inch valve and an "A" connection to main.

The eighth radiator (92 square feet on second floor) has a ¾-inch valve and an "A" connection to main. Note, as main approaches the end "D" connection is not used.

The end radiator on first floor is connected by 1¼-inch valve. The main must run full size 2 inches as close to last radiator as is possible.

The return starts back from last radiator 1¼ inches and increases through two sizes and ends 2½ inches at boiler. The total area of valves on this main amounts to 4.60 square inches. The area of a 2½-inch pipe is 4.90—it is evident, therefore, if for any reason an additional radiator became necessary it could be added without deranging the splendid circulation and efficiency

of this main, providing due care was given to size of valve and style and location of connection.

Main No. 2 starts $3\frac{1}{2}$ inches from boiler, is reduced through three sizes ("B" connections) ending 2 inches in last radiator. This main is 64 feet long and supplies 1021 square feet in thirteen radiators, distributed as follows:

One, on basement ceiling 81 square feet; five on first floor amounting to 363 square feet; four on second floor containing 319 square feet and three on third floor with 258 square feet.

We make first reduction from $3\frac{1}{2}$ inches to 3 inches through "B" connection at branch leading to 90 square foot radiator on first floor.

Second connection is a "D" leading to two radiators on different floors; a 1-inch riser runs to second floor and continues $\frac{3}{4}$-inch to third floor. Note "E" connection at 81 square foot radiator on first riser, as well as at 124 square foot and 20 square foot radiators on second and third risers.

Second reduction is made from 3-inch to $2\frac{1}{2}$-inch through "B" connection leading to 132 square foot radiator on first floor.

Third reduction is made from $2\frac{1}{2}$-inch to 2-inch through "B" connection feeding wall radiator on laundry ceiling. The main runs 2 inches from this point to end radiator, 90 square feet, which we connect with $1\frac{1}{4}$-inch valve. Return starts back $1\frac{1}{4}$-inch from end radiator, increas-

ing in size as need requires and ends 3 inches at boiler. We draw attention to separate return from the three radiators nearest the boiler. This, in keeping with our practice, must drop down separately to boiler so as in no way to conflict with main return. The total valve area on this main is 7.14 square inches. The area of a 3½-inch pipe is 9.62 square inches and that of a 3-inch pipe is 7.06 square inches, so that if necessity arose, more radiation could be added with due regard given to connection and size of valve used.

The installation here described is one of many of same type made for a builder who lends his name to nothing but the best in every line of construction. As these plants have been in successful operation for ten years, giving every satisfaction to all concerned, we recommend a careful study of the principles, sizes and adjustment involved. There have never been more satisfactory installations made. We will be pleased to give names and particulars of location on request.

Reduction of Mains.

If a 1¼-inch main is used starting at boiler, never reduce it, but extend full size to the end. If a 1½-inch main is used from boiler, it may be reduced one size (to 1¼-inch) but not smaller, and should be extended full size to the heel of the connection leading to the last radiator on the main. It is best, however, to extend a 1½-

inch main full size to the end; this will obviate the use of a "B" connection and separate returns to prevent possibility of short circuiting.

Never attempt to connect a 1-inch riser extending to a second (or higher) floor, to a $1\frac{1}{4}$-inch main; a $1\frac{1}{4}$-inch riser to a $1\frac{1}{2}$-inch main, nor a $1\frac{1}{2}$-inch riser to a 2-inch main. It can not be done successfully. The size of the main should always exceed the size of the riser by at least two commercial pipe sizes.

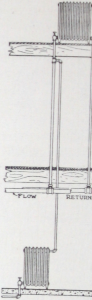
To secure a high velocity and even distribution of the water throughout the system, mains having a diameter of $1\frac{1}{2}$, 2, and $2\frac{1}{2}$ inches should not be reduced after leaving the boiler, more than one size. Example: a main starting at the boiler $2\frac{1}{2}$ inches should end 2 inches in last first floor radiator. Neglect of this advice invites all the sluggishness and likelihood of short circuiting found in old style, uncontrolled piping plans, wherein 2-inch mains were frequently reduced through three commercial pipe sizes ending at far end from boiler 1 inch and often in a riser extending to upper floors.

When mains are required, having a diameter of 3 inches or larger, it is permissible and practicable to make more than one reduction.

Branches connecting first floor radiators and risers to the mains should not be larger than the valves they are to supply, except where $\frac{1}{2}$-inch valves are used when the branches should extend $\frac{3}{4}$-inch.

We do not allow ½-inch branches or risers.

Size of Risers.



Sketch of Drop Pipi[n]
Supplying Baseme[n]
Radiators

The size of risers is computed by the same rule used for determining size of mains, except where a ½-inch valve is used on a second or higher floor radiator it is necessary to extend ¾-inch risers. When two radiators on a second or higher floor are supplied through ½-inch valves, ¾-inch risers are amply large to supply both. If a radiator on a second floor having a ¾-inch valve and a radiator on a third floor having a ½-inch valve were both to be supplied by one continuous riser, the riser from the mains to the second floor should be 1 inch an[d] from the second to the third floor ¾ inch. Th[e] combined area of the valves would be .64 squar[e] inch, and the nearest commercial size of pipe i[s] 1 inch, with an area of .78 square inch, there- fore, a 1-inch riser to the second floor and a ¾- inch riser to the third floor would be required. This same riser will easily supply two radiators on a second floor, having ½-inch valves an[d]

two radiators on a third floor with $\frac{1}{2}$-inch valves. Total area of four $\frac{1}{2}$-inch valves, .78 square inch.

Avoid long, horizontal branches between upper ceilings and floors by extending more and smaller risers.

Pitch of Mains and Branches.

When boiler is below radiation all mains and branches should pitch up from the boiler and high point in mains should be at far end from boiler.

For overhead jobs we strongly recommend that high point be made directly over boiler outlet; from high point mains should pitch downward, see sketch, page 50.

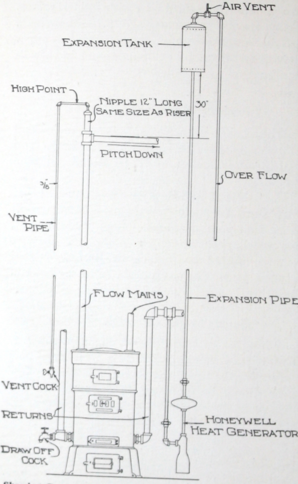
Pitch should be $\frac{1}{2}$-inch to 10 feet or just enough to properly vent air from mains and branches.

Supplying Basement Radiators.

When radiators are placed on basement floor or wall they should be fed by a drop pipe taken from near the top of the nearest flow riser. This riser should be increased to accommodate the basement radiator and a separate return installed, see sketch, page 48.

Connections.

We have devoted much time and thought to



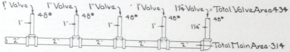
Showing Generator at boiler and detail of proper connections in overhead. Showing air chamber and vent pipe
See page 80 for Generator Connection

perfecting the proper connections to secure the most perfect distribution of water throughout the installation. The constant aim of heating engineers for years, has been to so balance and adjust the piping system as to cause each radiator to discharge warm water into the return pipe at practically the same moment. This represents the acme of perfection in the circulation of hot water and was impossible of attainment when all connections were slavishly taken off the top of the pipe in a manner we do not countenance.

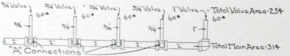
Taking all branches from the top (where runs the hottest water) could only result in one thing, viz., that first radiators should get all the water until the main had fed a valve area equal to its own. When this was accomplished the main became incapable and resulted in circulation weakening to vanishing point or in establishing a short circuit. By such connections radiators only moderately far from boiler were made altogether inefficient, through lack of circulation, to perform the task required of them. This condition was aggravated by the unintelligent reduction of a main as it advanced to far end and the total disregard of relation between main and valve areas.

The Honeywell Method has, by an intelligent adjustment of valve sizes and attention to proper distribution, made such enormities impossible.

An example will serve to show our meaning: Old-time, slip-shod methods allowed the use of five (we are very fair when we say five) 1-inch valves on a 2-inch main; this valve area amounts to 3.90 inches while area of main is 3.14 inches, an overload on main of .76 or just about the area of a 1-inch valve. If all five valves were full open at same time, obviously all could not get an equal amount of hot water at the same time, more particularly if connections were taken from the top of the main. We know of thousands of cases where the attempt has been made to feed seven or eight 1-inch valves through a 2-inch main.



OLD STYLE



THE HONEYWELL METHOD

It would be as sensible to say a dollar could be stretched at will to one hundred and seventy-three cents.

This overload cannot happen in Honeywell

Method; our valve area—proven right by tests and many thousand known installations—forbids such a practice and in place of five 1-inch valves on a 2-inch main as in example cited (or worse still, 7 or 8), we would use four ¾-inch and one 1-inch on end radiator, with combined area of 2.54, leaving an excess in favor of main of .60, or almost as great an excess as in first instance there was overload.

We will submit this to any thinking person: which is the more efficient main—the 2-inch with a .76 overload or the 2-inch with the .60 excess and which should be called the "small" pipe?

Our sketch shows a typical case and illustrates many important points.

We draw attention to the increased footage of radiation fed through each Honeywell Valve and the splendid margin of main over area of valves.

When we consider that old-style methods not only tolerated such a lay-out as here shown but usually reduced main as it advanced from boiler, we cannot be surprised that such a high percentage of old-style installations are quite unsatisfactory.

The overloading of mains is impossible in Honeywell Method as our rule is not subject to whimsical changes or rule of thumb calculations.

Some fitters in weakly defending their overload of mains have to admit that they cannot keep all valves full open all the time and that

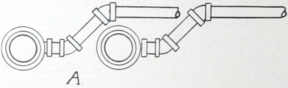
they have to "check them down" to effect proper circulation. This causes us to ask: Why should they be put on and make necessary a guess as to real opening into radiator?

Our mains are actually, as well as proportionately, bigger than the mains of many who pride themselves on "big" piping, but who cling to the illogical practice above described.

By our method of connecting branches to mains and use of intelligently sized pipes, we have succeeded in accomplishing the much desired result of a perfect circulation of water from a temperature of 85 degrees to 240 degrees.

Connections A, B, D, E and F shown here are all that are necessary in any hot water installation.

Connection "A."

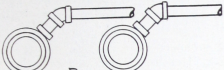


This connection is used, perhaps more than any one other and is designed to be installed wherever connections "B" and "D" are not, by our further description indicated as necessary.

Branches to first floor radiators from middle to outer ends of mains should be joined to the mains by "A" connection (see our sketch).

This connection should be made by the use of two nipples and two 45-degree ells.

Connection "B."

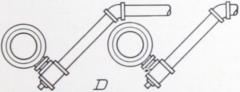


B

"B" is used wherever a reduction occurs in the mains and its duty is to relieve the air from the mains at this point, through nearest first floor radiator. Usually when "B" connections are used to join branch pipes to the main, the valve on the radiator is reduced one size, except where branch is very long.

Where a reduction occurs in the mains, branches to a first floor radiator should always be connected. Never connect riser branches at this point

Connection "D."



D

A good form of "D" Connection
for basement piping only

All branches to risers extending to second or higher floor radiators should be connected to the mains by a "D" connection for a distance of

about half the length of the main in ordinary residence work and in all cases for a distance sufficient to prevent possibility of short circuit.

Do not use "D" connection when there is a long branch between main and riser—substitute "A."

The intelligent use of "D" connections will insure a vigorous, responsive circulation at extreme ends of mains. Its mission is to prevent the first radiators from getting all the best of the circulation; this is accomplished by taking the water from where it is the coolest.

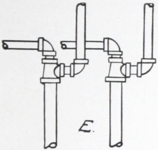
There is no one connection that will so successfully equalize the circulation on all floors and prevent short circuiting in any part of the system. Any heating contractor who has made use of "D" connection appreciates its value as a distributor and uses none other where "D" will apply.

When "D" connections are used the 45-degree ells should be tapped at the bottom and a ⅛-inch pet cock inserted for the purpose of draining. As the proportion of "D" connections to other types is about as 1 is to 7 this extra precaution should not be considered a great burden.

Connection "E."

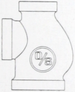
Connection "E" illustrates the correct method of taking off branches for a second or higher floor radiator and extending a riser to the floor above. Risers extending higher than to a second

floor should be broken or offset at point below connections to radiators on intermediate floor. The branches from second floor radiators should



E.

connect into the top openings of the tees and risers extending to the next higher floor should connect into the side openings of the tees. Simple as it seems, disregard of this advice has resulted in perversions of circulation that were incurable.

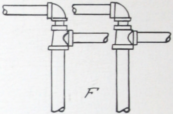


O. S. Distributing Tees, designed especially for this purpose, are superior to connection "E" and are cheaper to install.

Connection "F."

This connection indicates the correct method of connecting two radiators to one pair of risers

on a second or higher floor. The branches from a larger radiator should connect into the top of the tees and the branches from the smaller radiator into the side of the tees.

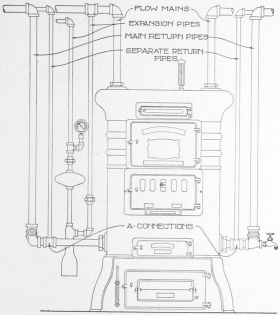


A little study of our method will show that we have struck a very happy and successful medium between the old system that created an overload on boiler by too many small mains and the equally bad idea of installation that through use of one or two huge mains resulted in same foolish overload with resultant sluggish circulation.

Separate Returns.

It is imperative that the return pipes from radiators near the boiler be connected directly into the return header or boiler, and that they should not be connected into or conflict with main return pipe (see illustration of this idea in our sketch, page 59). Usually a size smaller valve than our list indicates may be used on radiators connected in this way, or at all events, they will bear some reasonable extension of sizes. If there are no extra tappings at the

boiler, the shell of the boiler may be tapped, as the pipes are small, or a tee may be inserted in the *Horizontal portion of the main return pipe near where it enters the boiler.* (See our detail of separate returns.)



Showing how to connect separate returns at boiler
See page 80 for Generator Connection

The small return pipe should enter the tee through an "A" connection. This is important. *Never insert this tee in the vertical portion of the main return pipe.*

It is bad practice to connect the return pipes from radiators near the boiler, directly into the main return pipe, because such radiators generally circulate more quickly than those farther away and discharging warm water into the main return pipe, slow up the circulation through the whole main and its connecting branches.

We strongly condemn the practice of indiscriminately taking "branches from branches;" it should not be attempted unless under exceptional conditions or where to do otherwise would entail needless expense or labor.

Go back to the main for each group of radiators. Thus, only, can perfect control of plant be secured.

Control.

The Honeywell Method of Piping affords complete control of system by dividing the building into separate portions; by placing valves on branches from mains it is made possible to cut out one or more radiators on each floor, if for any reason the necessity for repairs arises.

When we remember that in the old, ponderous style systems it was necessary to cut out the whole floor or section of a building to effect any slight repairs—we see an additional advantage in the Honeywell Method. By our piping plans there are seldom two radiators in succession on one floor taken from one branch; the superiority of control is plainly apparent.

This control of units of radiation, together with control afforded by Honeywell Thermostat and Honeywell Water Regulator (or limiting device), gives the proprietor the means of regulating his installation in a manner not even attempted in ordinary systems.

Reaming Pipe.

It is of great importance that all pipe ends be thoroughly *reamed,* not only to prevent the lodgment of sediment but to remove the cause of swirling water and eddies, and provide an easy and continuous flow and high velocity of the water.

A burr left on a pipe end, has the effect of practically reducing the area of the pipe one size. As all pipe sizes in the Honeywell Method are carefully calculated, the importance of thorough reaming will be appreciated.

Pipe Dope.

Steam fitters should avoid the use of thick, viscous dope in making up pipe joints. Good sharp threads with a little oil are best.

Expansion Joints.

Expansion of long runs of pipe should be provided for by supplying swing joints at the ends of the mains. In ordinary residence jobs it is not necessary to make such provision.

The following table will be of interest:

Expansion of Wrought Iron Pipe.

Under temperatures from 215 to 338.

Temperature of the Air when Pipe is Fitted	Length of Pipe when Fitted		
		215°	265°
Zero	100 ft.	100 ft.–1.72 in.	100 ft.–2.12 in.
32	100 ft.	100 ft.–1.47 in.	100 ft.–1.78 in.
64	100 ft.	100 ft.–1.21 in.	100 ft.–1.61 in.
		297°	338°
Zero	100 ft.	100 ft.–2.31 in.	100 ft.–2.70 in.
32	100 ft.	100 ft.–2.12 in.	100 ft.–2.45 in.
64	100 ft.	100 ft.–1.87 in.	100 ft.–2.19 in.

The Generator.

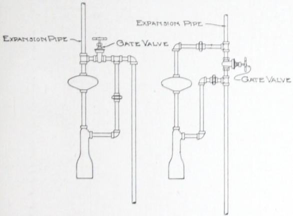
The best place to locate the Generator is in the basement near the boiler.

Connect the side opening of the Generator direct to a tee provided in any flow or return pipe in manner illustrated in our sketch, page 64.

Use a union or right and left to make this connection and do not screw the Generator on by turning it over and over. After the Generator is joined to the main connect the expansion pipe to the top opening of the Generator, using a union, and extend as directly as possible to the expansion tank.

Frequently it is desired to connect a Generator to the expansion pipe of an unsatisfactory job. If the expansion pipe does not extend to the boil-

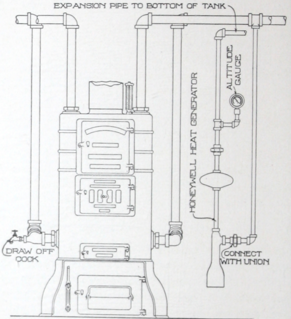
er, but is taken from a return connection of some radiator upstairs, locate the Generator at the most convenient point, allowing it to rest on the floor and connect just as already described.



Cuts showing two methods of connecting Generator with by-pass

Do not suspend the Generator close under the expansion tank. There should be at least thirty inches between top of Generator and bottom of the expansion tank (see our cut of arrangement for upstairs connections). The Generator performs its function equally well whether it be located at the boiler or on first, second or higher floors, but needs above distance to allow water to flow easily back to system. Do not expect the Generator or the expansion pipe above the Generator to become hot, as there is no movement of water through the Generator other than that

which is expanded through from the system when water is heating or that which flows back through from expansion tank when water cools and contracts.



Cut showing connection of Generator to mains at boiler
See page 80 for Generator connection

If water in system is heated to a high temperature, causing a considerable quantity to be expanded through the Generator and expansion pipe into the tank, the Generator and expansion pipe may become warm, the natural result of passing hot water.

The Generator is caused to operate and produce a pressure by the expansion of the water in the heating system. When the fire is started the water heats and is expanded. As the water increases in volume it endeavors to pass through the mercury in the lower chamber of the Generator, and in its effort drives the mercury upward into the stand pipe and circulating tube—thus producing a pressure, reaching its maximum when the mercury has risen to the top of the circulating tube, when the mercury begins to circulate up and down through the two tubes quite rapidly. When this position of the mercury is attained, the excess water of expansion is carried upward with the flowing mercury, and passes freely and noiselessly into the expansion tank.

An expansion or increase of volume of water in the system amounting to six fluid ounces, causes the Generator to produce its maximum pressure. Only under a rising or sustained temperature of the water is it possible or desirable to produce and maintain pressure; any pressure of from 0 to 10 pounds, in exact keeping with variations in water temperatures.

Air.

Air is the most persistent enemy of hot water installations the heating contractor has to contend with.

Provision must be made for eliminating the accumulation of air from the system and for

keeping the installation as free as possible from this arch enemy. A radiator or pipe air-bound is out of commission as water will not circulate through any portion of the installation thus hampered. A pipe trapped or pitched the wrong direction a height equal to its own diameter will allow a collection of air that will shut off circulation as effectually as a valve and any trap in piping will be proportionately harmful. We give, in another part of this booklet, advice as to filling of system and care of radiators.

One great cause of air trouble is improper method of taking connections off mains.

At each reduction in main provision must be made to take off through a near-by radiator, any collection of air, otherwise the larger pipe will be of no greater effective area than the size to which it is reduced.

A study of our typical plan, opposite page 46, and our detail of connections, will show the care we exercise to avoid this needless air trouble.

A second cause is to be found in placing expansion tank close to highest radiator, or in using a tank that is too small.

When tank is too close to top of highest radiators there is not sufficient static head to allow water of expansion to return to system quickly enough to prevent entry of air to radiators.

When tank is too small any expansion of water will overflow it and when later on water by cool-

ing has contracted, tank is empty and expansion line or top radiators are exposed to atmosphere.

Noting the swirling effect (with void in center) of water flowing down a basin, or from like receptacle, will serve as an object lesson to those who will apply it.

Air is the most elastic gas known and may be reduced to a liquid by compression, therefore, we would warn everyone against the use of devices in which it is necessary to compress air before a pressure is obtained on the system. There are several such offered, under names that would indicate a resemblance to Honeywell Generator. They are totally different and are wrong in principle. They depend on high water temperatures to expand the water enough to compress the air in the tank. This procedure requires excessive temperatures to create any perceptible pressure and the means defeat the end, because, obviously, when extremely high temperatures are necessary to create pressure, pressure becomes unnecessary through the very creation of such temperatures.

Mechanical devices for promoting pressure, depending on springs, weights or the contact of two metals or other materials, are objectionable for two widely different reasons. First, there is the likelihood of disaster following their sticking, as radiator valves frequently do, or refusing to release at pre-determined pressure, and second, they are rendered inoperative through lodgment

of any minute particles of sediment on their faced joints or valve seats. It is poor logic, indeed, to accept any substitute advertised as "just as good." The Honeywell Generator is recognized as standard and is fully protected by United States and foreign patents.

On account of the extreme mobility of mercury used in the *two* tubes of the Honeywell Generator, it is a mechanical impossibility for it to hold above ten pounds pressure or to be invalidated by sediment or precipitation in the water.

When the Honeywell Heat Generator is used there can be no increase in temperature of water, irrespective of starting point, without a relative increase of pressure, nor can there be any falling off in temperatures without like pressure decrease.

A consideration of the construction of the Honeywell Heat Generator will show clearly that pressure is being produced the moment the fire is started in the boiler.

The Generator should be connected to system by unions so that it may be easily disconnected if for any reason a building is left without fire in cold weather for any extended period of time.

Draining Cock.

The draining cock should be located at the opposite side of the boiler from the Generator connection (see illustration, page 64).

The Altitude Gauge.

When the Generator is located at the boiler, the best place to connect the altitude gauge is in the expansion pipe above the Generator. When so connected, the pressure produced in the Generator will not be indicated on the gauge and the exact height of water in the system will always be registered (see illustration, page 64).

When the altitude gauge is connected to the boiler, or on pressure side of the Generator, the pointer will vary as the changes in water temperatures cause the Generator to produce pressures, in addition to static head, ranging from 0 to 10 pounds.

The altitude gauge should indicate height in keeping with following table:

Static Pressure of Water for Each Foot in Height.

Height in Feet	Pounds Per Square Inch
5	2.16
10	4.33
15	6.49
20	8.65
25	10.82
40	17.32

This table indicates that water exerts a pressure of .433 pounds per foot in height. We say approximately that every foot elevation is equal to half a pound pressure per square inch.

The Thermometer.

If accuracy of temperature is desired, the thermometer should be connected direct to the top of the boiler. The mercury cup of the thermometer should extend through the boiler shell and be immersed in the water.

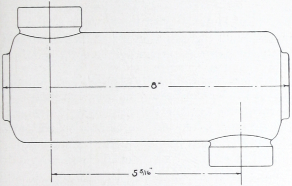
The Expansion Tank.

As the water is heated from 40° to 212° it increases in bulk—the degree of expansion being approximately one-twenty-third of its volume. The expansion tank should be of capacity to easily accommodate the increase in bulk through 200 degrees range of temperature, plus a safe margin to replace water lost through evaporation or otherwise and to prevent the entry of air into the system.

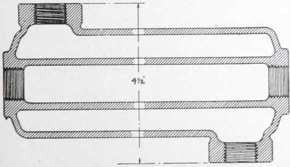
Many heating contractors cause themselves and proprietors needless work and expense by altogether inadequate size of expansion tank used. Indeed, the idea prevails in many cases that it is necessary or at least unavoidable that water be lost from system through expansion. This is clearly erroneous, as any water lost must be replaced by new cold water at a useless cost in operation of plant and must be replaced at once or air troubles are the inevitable result.

Water lost through overflow is coal thrown out of doors and can be obviated by an expansion tank of size suitable to "hold" water of expansion.

As a square foot of radiation contains about one pint of water the number of square feet in radiation, plus about 20 per cent for piping and boiler divided by eight will give contents in gallons. One-twenty-third of this figure will be the



TAPPED 3/4" ALLAROUND



Cut showing Circulators

amount that should be "held" in expansio tank.

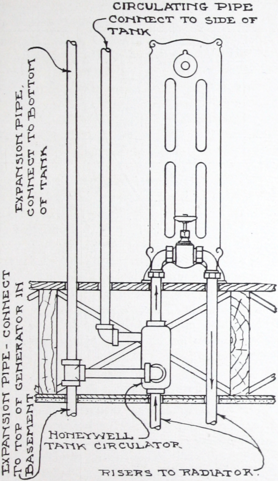
It is important that the expansion tank be nc less than thirty inches above the highest radiat or. It may be connected to the return pipe of on of these but we strongly recommend that the ex pansion line extend back to the basement. A ven pipe must be taken from the overflow at the to of the tank, providing an outlet to the atmos phere, making the system permanently open.

It is important to have expansion tank so larg that it will be unnecessary to keep it overflowing as in severe weather the possibility of freezin the overflow is one not to be overlooked. W recommend, when possible, that overflow be conducted to some sink or cistern in the house.

Expansion pipe should be run in or on inside walls and well protected against freezing. When it is necessary to place the tank in a cold spot, the tank and pipes should be thoroughly insulated or provision should be made for circulating the water within it. This can be splendidly done by the use of the Honeywell Tank Circulator, illustrated, page 71.

The easy adaptation of this device shown in our cut, page 73, makes it of great importance at a very low cost.

The following sizes of tanks are safe to use for the quantities of radiation specified:



How to connect the Tank Circulator

Size	Gallons	Square Feet of Radiation
10x20 in.	8	250
12x20 in.	10	300
12x30 in.	15	500
14x30 in.	20	700
16x30 in.	26	950
16x36 in.	32	1300
16x48 in.	42	2000
18x60 in.	66	3000
20x60 in.	82	5000
22x60 in.	100	6000

Expansion tanks which automatically suppl the system with water are perhaps the best typ of tank to use, as they insure the radiators al ways being kept full. They are not unsightly an can be used to advantage in many places wher the cylinder type cannot be adopted; the usually can be put in a closet, hall or back room thus eliminating all danger of freezing. (Se cut, illustrating automatic tank.)

Expansion tank should always be thirty inche or more above the top of the highest radiator ir the building.

Where to Fill the System.

The filling connection should be placed *be-tween* the Generator and the boiler or directly into the boiler or any return pipe near the boiler.

When system is filled the first time from automatic tank provision should be made for by-passing Generator, as per our sketch, page 76.

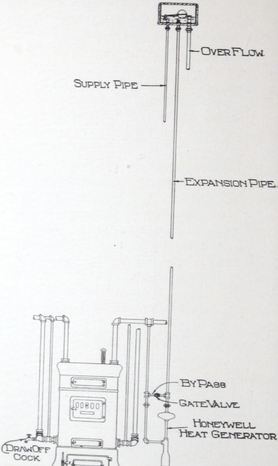
When system has been filled through connection provided, the expansion tank will serve to keep plant filled to proper height and if placed at a point at least thirty inches above highest radiator, will eliminate one great cause of complaint—collection of air in top floor radiators.

Pipe and Boiler Covering.

If heat is not desirable in the basement, the pipes and boiler should be thoroughly insulated. Piping passing through a cold cellar loses more heat than equivalent amount of piping or radiation in a warm room. This is explained when we remember that the heat emission of a radiator increases with the difference in temperature of the water in the radiator and the air surrounding it. Heat thus lost is needless tax on boiler and fuel.

Hints to Heating Contractors.

When the material is on the ground and the heating contractor has commenced the job, he should stick to it until it is completed. Many a house owner has been dissatisfied with his job because the work has dragged on almost interminably. After the job has been completed and filled with water, it should be fired *and most thoroughly tested.* The heating contractor should satisfy himself that the water circulates through all radiators evenly and rapidly. He should see that a circulation through every radiator in the



Cut showing automatic tank with Generator at boiler
Shows also by-pass

house can be established at a temperature as low as 85°; later let him show that this same beautiful circulation can be maintained when the temperature is higher than that of an ordinary steam plant.

He should see that water circulates evenly and rapidly at any temperature point between 85 and 240. It would then be well to make the house owner acquainted and conversant with his job; show him how to fill it; how to fire it; how to adjust the dampers; how and when to vent the air from the radiators, and insist that the boiler flues be frequently and thoroughly cleaned. Let him know that a deposit on his boiler flues of 1/4 inch may increase his coal consumption a full 50 per cent. If deposit is allowed to incrust and harden the increase in fuel waste is greater. With all this, do not desert the house owner, and later on, if he comes in with a complaint, in most cases trouble will be found in improper handling of the fire.

A little patience and an occasional visit to the job will do wonders towards satisfying the customer and will return for time thus spent a hundredfold in good will and future business.

Unsatisfactory Jobs.

We are frequently asked to suggest means for improving the old style, water-logged, uncontrolled, hot water installations. If heating con-

tractor is called upon to correct some such system, we would advise him to go carefully over the whole installation. Check up radiation amounts boiler size, condition and size of chimney; ordinary condition of fire, ash pit, kind of coal used. Ascertain how much harm coil (if any), for heating range boiler, in fire pot is doing; consider the attention given to proper firing—learn the frequency of firing period and whether customer maintains a steady or variable water temperature.

If variable temperature, strike an average and see if such average temperature could possibly heat the house with the amounts of radiation installed. For instance, if the radiation has been figured on the basis of 180° boiler temperature and the householder maintains an average of somewhere about 130°, the answer would be plain.

Check up pipe sizes carefully—if the valve area exceeds the area of the main, the radiators cannot all work equally well at the same time; very often an intelligent reduction of valve sizes with due regard to location of radiator on main is sufficient to cure some local ailment.

See that thermometer extends into water; test circulation by taking temperature readings at different or all points.

If any radiator shows a marked variation from others, consider why this variation is and how it can be cured.

See that at each reduction in main provision for taking off the air is duly made; see that such reduction be not made through the radiator on upper floors. Consider that if reductions are not properly vented the larger pipe is of no greater efficiency than the smaller one.

See to it that mains favor somewhat the lower floor; it is no trick to get hot water to go to upstairs radiators—it sometimes is, to keep it down.

Look over chimney and smoke pipe and see that they both are in keeping with what the boiler size and radiation amounts require, as well as other qualifying local conditions.

Compare size and location of expansion tank with what they should be and determine if they are adequate.

Do not jump at conclusions and risk the humiliation of being proved wrong; do not at once condemn the boiler or the piping or any one particular feature, settling the argument with a wave of the hand.

It is so much easier to criticize destructively, than to suggest improvements under guarantee that it is often the refuge of an incompetent; a careful study of all conditions, however slight they may appear, will well repay itself.

In a large majority of such cases, where the trouble is not due to too much of a shortage in boiler capacity, or a bad draft, a Generator of

the proper size connected into the expansion pipe of the job will materially benefit or entirely cure the trouble.

Should a Generator be connected to such a job without satisfactory results, we will then be pleased to look over your data and be of assistance.

Placing the Generator.

In new work we advise connecting the expansion pipe and Generator to one of the flow or return mains above the boiler, as shown on pages 50, 59 and 64.

This connection is preferable, for the reason that should boiling temperatures of the water ever be reached, through carelessness or inattention to drafts on uncontrolled plants, syphoning of the water from the boiler down to a dangerously low level will be positively prevented; as the water level can only lower to the connection in the mains.

In the ordinary operation of a plant it makes no difference whether the expansion pipe is taken from a flow or return; but for the reasons above given we advise connecting the expansion pipe to one of the mains above the boiler.

The Honeywell Tank-in-Basement Method of Hot Water Heating

For bungalows, one-story or flat roof buildings, where it is difficult to place the expansion tank of a hot water heating plant above the radiators, or where it is liable to freeze, we strongly advise the Honeywell Tank-in-Basement method.

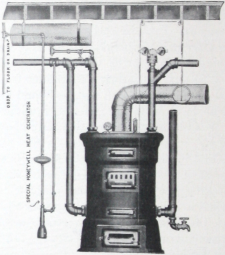
This extremely simple and dependable method of placing the expansion tank in the basement where it is out of the way and cannot freeze, is one that will appeal to all architects and heating men who have in the past found it difficult or unsightly to locate the expansion tank above the radiation.

It is not intended that our Tank-in-Basement method shall take the place of our regular method of installing hot water heating systems, but in such cases as are mentioned above, we recommend it. An intelligent use of both methods will result in the greatest possible improvement in hot water heating practice.

Special Honeywell Heat Generator

A Honeywell Heat Generator, built especially for our Tank-in-Basement method, gives positive relief at a pressure of ten pounds. This small amount of pressure increases the efficiency of the heating plant and makes it more responsive to firing.

The principal difference between the regular Honeywell Generator and the Special Tank-in-Basement Generator, is in the height of the standpipes. In addition to generating ten pounds pressure, the Special Generator holds the water up in the radiators, making necessary higher standpipes and more mercury.



Special Honeywell Heat Generators are manufactured regularly in three sizes, known as Nos. 11, 12 and 13, with standpipes of different heights to properly take care of buildings having 1, 2 and 3 stories and basement, and containing 2,500 square feet or less of radiation. Equipment for plants containing more than 2,500 square feet of radiation will be furnished on special order.

Regular Pattern Generators Can Be Used

By a very simple method of installation, our regular pattern Honeywell Heat Generators give excellent results in Tank-in-Basement work. As shown by the accompanying cut, our regular pattern Generators are installed the same as in the ordinary system, the only difference being that in place of the expansion pipe extending from the Generator to the expansion tank, an overflow, or relief, pipe is carried in any convenient place in the building to a point as high as the top of the highest radiator and serves as a standpipe.

From the highest point of the standpipe a vent must be taken, as shown in the cut, and the overflow pipe extended or dropped to the nearest drain; this line, as with all overflows, should be galvanized pipe.

With our standard Generators installed as described above, the water is not held up in the radiation by artificial means as the standpipe extending upwards from the Generator stands full of water and balances the column of water in the system.

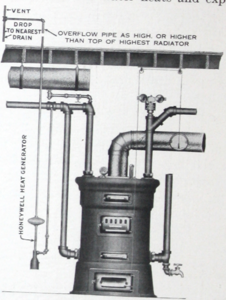
The Generator installed in this way has nothing to do but develop the 10 pounds pressure, which forces the water of expansion into the tank in the basement, when the temperature increases.

This method insures the radiators being kept full of water and there is no possibility of the

water being syphoned from the system, as th
discharge is at the high point.

Operation of Both Methods

When the system is filled the air in the tank i
slightly compressed and only a little water enter
the tank. When the water heats and expands



the pressure produced by the Generator prevents the water overflowing through the standpipe and forces it into the tank, further compressing the air. When the water cools and contracts, the compressed air forces it back into the piping;

thus the system is kept full of water at all times. Only the surplus expanding water forces through the Generator and out through the overflow.

By suspending the expansion tank near the basement ceiling and taking the expansion pipe from the top of a flow main and extending to bottom of tank, the air in the circulating water finds its way up into the tank. This automatically keeps the tank supplied with air at all times.

In the expansion pipe to the tank (see cut) a valve is placed and a tee where the line enters the tank.

If, for any reason through long use, the tank should become water logged, it can be emptied without draining the system by simply closing the valve in the expansion line and removing the plug from the tee. When the tank is empty this plug is replaced and the valve is again opened.

The Expansion Tank

It is important with a Tank-in-Basement system that the expansion tank be air-tight. To insure this a brazed or electric welded air-tested tank, with no tappings above the water line, should be used, or an ordinary riveted expansion tank or range boiler may be used after the following treatment:

All openings in tank should first be plugged except the one on the side which will be used for

expansion pipe connection, then tank should b
heated by setting near stove, radiator or ov
register, or it can be warmed with a blow torc
Then pour about one quart of hot asphaltum int
the side opening and turn tank so that asphaltur
will run over all joints after which surplus aspha
tum should be drained out.

If there are unused tappings that come abov
the water line, or more than a third of the way u
from the bottom, when the tank is swung horizon
tally, the plugs should be put in with red or whit
lead before applying asphaltum and gone ove
with soapsuds after system has been filled to se
that there are no air leaks.

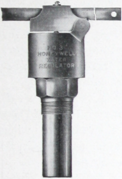
Tank Capacities

On plants containing 600 sq. ft. or less of radiation, a 21-gallon tank should be used; on from 600 to 1,000 sq. ft., a 30-gallon tank; two 30-gallon tanks on from 1,000 to 2,000 sq. ft., or a 40-gallon tank may be used on plants containing from 1,000 to 1,400 sq. ft. of radiation. Tanks for larger plants in proportion. On account of the growing demand, jobbers are stocking air-tight tanks and they can now be readily obtained at about the same prices as riveted tanks.

Perfect Regulation

The water in a Tank-in-Basement system is held up in the radiators by artificial means and must not boil. Any formation of steam would

quickly force the water down and out through the relief pipe. To prevent this we furnish regularly with all Honeywell Tank-in-Basement equipment our No. 3 Honeywell Syphon Water Regulator or



3-A if Arco boiler is used. These instruments perfectly control the heater drafts by means of water temperature—the only way effective regulation can be obtained.

Regulation by pressure is not dependable. This is a feature of considerable importance, for the pressure constantly varies in a Tank-in-Basement system, and as the pressure varies, the setting of the regulator must be changed.

With a regulator that operates on pressure, the slightest addition or loss of water from the system will throw it out of adjustment. The venting of a radiator will also throw the regulator out of adjustment. With our No. 3 Water Regulator, the quantity of water or air, or the variation in

pressure does not affect its operation since it is controlled entirely by the temperature of the water.

By moving the weights in or out on the lever, any desired temperature of the water in the system, between 100 and 220 degrees, may be maintained as long as there is fire in the boiler. Being sensitive to any temperature change, a rise or fall of 2 to 3 degrees will cause the regulator to open or close the dampers.

The Honeywell Temperature Regulator, controlling the dampers through the temperature of the rooms above, can be used with perfect results with this method, operating in connection with the No. 3 Water Regulator.

When regular pattern generators are used in Tank-in-Basement work, our No. 3 Water Regulator is not essential, but can be used to advantage.

Tables of Pipe Factors.

The following tables will be found of use in converting lineal feet to square and square to lineal:

Lineal to Square	Square to Lineal
¾ in. x .275	¾ in. x 3.637
1 in. x .334	1 in. x 2.994
1¼ in. x .434	1¼ in. x 2.30
1½ in. x .497	1½ in. x 2.012
2 in. x .621	2 in. x 1.160
2½ in. x .752	2½ in. x 1.33
3 in. x .916	3 in. x 1.090
3½ in. x 1.047	3½ in. x .955
4 in. x 1.179	4 in. x .848

Example: 300 feet of 1½-inch pipe multiplied by factor .497 equals 149.1 square feet.

Example: 149.1 square feet of surface multiplied by factor 2.012 equals 300.1 feet of 1½-inch pipe.

Equation of Pipes.

To reduce pipes of different sizes to their equivalent in 1 inch, following factors are sufficiently accurate for ordinary purposes.

1¼ in. x 1.26	1½ in. x 1.44	2 in. x 1.81	2½ in. x 2.19	3 in. x 2.66	3½ in. x 3.04
4 in. x 3.42	4½ in. x 3.80	5 in. x 4.23	6 in. x 5.03	7 in. x 5.80	8 in. x 6.55

Example: 5000 ft.–1¼ in. x 1.26
4000 ft.–2½ in. x 2.19
2000 ft.–3 in. x 2.66=20,380 ft. of 1-in
pipe, or 6,807 square feet of radiation.

From the above we make following close a
proximations:

36 inches–1 in. pipe	Equals one sq. ft. radiation.
28 inches–1¼ in. pipe	
24 inches–1½ in. pipe	
20 inches–2 in. pipe	
16 inches–2½ in. pipe	
13 inches–3 in. pipe	
12 inches–3½ in. pipe	
11 inches–4 in. pipe	
10 inches–4½ in. pipe	
9 inches–5 in. pipe	
8 inches–6 in. pipe	
7 inches–7 in. pipe	
6 inches–8 in. pipe	

Pressures and Boiling Points of Water fo Given Static Heads.

Height of Column, Feet	Pressure Per Square Inch at Boiler, Pounds	Boiling Point at Boiler, Degrees Fahrenheit
2	0.866	214.9
5	2.165	219.0
10	4.330	225.3
15	6.500	231.0
20	8.660	236.2
25	10.830	241
30	12.990	245
40	17.320	253.8
50	21.650	261.3

The above table will explain very clearly the
value of the Honeywell Generator. As mercury
is about thirteen times heavier than water, a

column of mercury twenty-one inches in height would exert the same pressure as a column of water twenty-two and three-quarter feet and raise the boiling point of water thirty degrees.

Horsepower of Boilers.

Because it is sometimes necessary that a Heating Contractor should calculate and determine "in horsepower" the capacity of a certain boiler, we give the following definitions:

It is an empirical term applied to boilers that meet the following requirements of high pressure engineers:

1 square foot of heating surface will evaporate from 2 to 6 pounds of water from and at 212 degrees Fahrenheit.

34.5 pounds water evaporated from and at 212 degrees Fahrenheit equal one horsepower.

1 square foot cast iron radiation will condense ¼ pound of steam per hour with 2 pounds gauge pressure at boiler, 70 degrees temperature in the room.

It is roughly assumed by some for calculating purposes that:

30 pounds of water, evaporated, equal 1 horsepower.

15 square feet of heating surface equal 1 horsepower.

1 horsepower will supply 100 square feet of radiation.

While properly the term, "horsepower," can-

not have any proper application in house heating boilers, there are times when above information will be appreciated.

The boiler horsepower is equal to evaporation of 34½ pounds of water.

Example: 34½x966 B. T U.=33327.

To find horsepower required compute heat loss in B. T. U. and divide by 33,330.

Properties of Water.

Water presents a singular exception to the general law of expansion by heat. If water at 39 degrees is cooled, it expands as it cools till reduced to 32 degrees, when it solidifies in the form of ice; and if water at 39 degrees is heated it expands as the temperature difference increases in accordance with the general law.

Water expands at a constantly accelerated rate with each degree rising temperature.

The following data is quite accurate enough for ordinary calculations:

1 cubic foot of water, or 7.47 U. S. gallons, weighs 62.5 pounds.

1 cubic inch of water weighs .036 pounds.

6 imperial gallons equal 1 cubic foot.

1 U. S. gallon weighs 8.33 pounds and equals 231 cubic inches.

1 imperial gallon weighs 10 pounds and equals 288 cubic inches.

Water boils in open vessel, at atmospheric pressure, sea level, at 212°.

Table of Boiling Temperatures.

Boiling Temperatures	Absolute Pressure Per Square Inch	Vacuum Expressed in Inches
157	4.408	20.94
161	4.851	20.04
165	5.333	19.06
169	5.855	18.00
172	6.273	17.15
176	6.867	15.94
179	7.344	14.97
182	7.85	13.94
185	8.38	12.85
187	8.76	12.09
190	9.34	10.90
192	9.74	10.09
194	10.17	9.21
197	10.83	7.87
199	11.29	6.93
201	11.76	5.97
203	12.26	4.96
205	12.77	3.92
207	13.30	2.84
209	13.85	1.73
210	14.13	1.16
212	14.70	
215	15.60	
217	16.22	
219	16.86	
222	17.87	
225	18.91	
227	19.64	
230	20.77	
232	21.56	
235	22.79	
237	23.64	
240	24.97	
242	25.88	
244	26.83	
246	27.80	
248	28.80	
250	29.82	

Water boils at lesser temperatures than 212° when atmospheric pressure is less and at greater temperatures than 212° under pressures greater than atmospheric. It is fairly accurate to say that 3° Fahrenheit temperature are added or subtracted as pressure increases or decreases one pound.

We draw your attention to the fact that at 20.94 inches of vacuum or as some wrongly call it, 10 "pounds" of vacuum, the boiling point is 157 degrees Fahrenheit. As 20 inches of vacuum in house heating are difficult to attain and much more so to maintain, the short range of even very good vacuum systems as compared with the Honeywell Method is made manifest.

Water expands in heating from 39° to 212° one-twenty-third, or about 4 per cent.

Water has greatest density and occupies least space at 39° Fahrenheit.

A square foot of radiation contains approximately 1 pint of water.

Water in circulation is the best known absorbent of heat and an excellent conveyor and gives off more heat in cooling through a given range of temperature than any known substance.

Useful Information and Data.

A British Thermal Unit or B. T. U. is the quantity of heat required to raise one pound of water 1 degree Fahrenheit.

One B. T. U. will raise 1 cubic foot of air 50° or 50 cubic feet of air 1°. To be exact, 48.77 cubic feet.

To evaporate 1 pound of water into steam from and at 212° requires 966 B. T. U.; as 1 square foot of steam radiation emits about 240 B. T. U. per hour, we see it will require just 4 feet of radiation to condense a pound of steam, or, in other words, to transmit 966 B. T. U. to the air of the room.

The rate of emission through 1 square foot of hot water radiation at a temperature at the boiler of 180° and 70° in the room is approximately 150 B. T. U.

Area of Circles.

To find area of a circle multiply square of its diameter by .7854.

To find circumference of a circle when diameter is given, multiply given diameter by 3.1416.

Diameter of circle, when circumference is given, is found by multiplying given circumference by .31831.

Areas of circles are to each other as the square of their diameters.

Hints on Coal.

50 pounds of hard coal occupy space equal to 1 square foot of grate.

40 pounds of soft coal occupy space equal 1 square foot of grate.

20 pounds of coke occupy space equal 1 square foot of grate.

A ton of hard coal occupies a space equal 37 cubic feet.

A ton of soft coal occupies a space equal to cubic feet.

Three tons of hard coal to a load of 100 squa feet steam radiation, is the estimated fuel co sumption for an ordinary winter.

A ton and one-half of hard coal to 100 squa feet water radiation is an ordinary calculatio

Quantity of Water Lost by Evaporation.

The quantity of water that is lost by evapor tion is very trifling, not as much, in ordinar installations, as ten gallons in a heating seaso

Evaporation should be the only means of los water should not be drawn off boiler or radia tors for any domestic purposes—and expansio tank should be large enough to provide storag for all water of expansion, without overflowin

Whatever water is drawn off or allowed t overflow from expansion tank must be replace by like amount of cold water—automatically i so arranged, or by opening feed cock if neces sary. This introduction of cold water is need lessly expensive and introduces an element o trouble in letting in a quantity of air propor tionate to bulk of water lost. We repeat: the

only loss from a plant should be that by evaporation and is under proper conditions of installations, quite negligible.

Corrosion and Precipitation.

Many heating men in thinking of corrosion, make the mistake of confounding a hot water heating plant with the apparatus for supplying water for domestic purposes. The conditions are so different as to make the comparison ridiculous. In a house heating hot water plant the quantity of water that could possibly have any corrosive effect or tend to precipitate any foreign substance, is the original charge, plus quantity lost each year by evaporation.

Let us consider a house of 1,000 square feet of radiation. Such a plant would contain at most 150 gallons—Honeywell Method. Loss by evaporation would make load of 160 for first year and 10 gallons each succeeding year. The total quantity passed through plant in ten years would be about 250 gallons—let us say 300 at outside. Now, let us assume that in a domestic service the daily use would amount to 30 gallons a day for baths, kitchen use, laundry, etc., etc. It is apparent that as much "new" water passes through domestic coil and tank in ten days as would be used in house heating plant in ten years. In other words—the house heating plant would remain free from corrosion and precipitation as many years as the domestic service appa-

ratus would days. Comparison is unworthy of thought. There is no record of a pipe used for house heating in manner it is designed to be used, becoming corroded or "choked up." We have acquired and examined pieces of piping that have been in use thirty-five years, in different localities, with all kinds of water, and the extent of corrosion was a "slime" that could be wiped off with the finger and pitting less than 0.003 inch.

Corrosion is a "bugaboo" raised by an unthinking few; all that is necessary is to keep the plant full of water at all times.

Choked Expansion Line.

Others cite choking up of expansion line—failing to appreciate the fundamental difference between the circulating pipes of hot water system always filled with same water all the time and closed from atmosphere, and the expansion line wherein there is no circulation, filled with a column of water of varying heights, the head of the column exposed to the atmosphere.

The expansion line of a system may in course of many years, dependent on surrounding conditions, corrode and close up.

The Honeywell Method, by exacting a line to expansion tank of proper area minimizes this danger but cannot, any more than any other systems, completely efface it.

The architect or heating contractor who tolerates a $\frac{1}{2}$-inch expansion line and who listens to talk of corrosion in a 1-inch or $\frac{3}{4}$-inch circulating pipe, always filled and sealed from the atmosphere is strangely inconsistent.

The heating contractor who accepts as necessary, 1-inch, $\frac{3}{4}$-inch, $\frac{1}{2}$-inch or $\frac{3}{8}$-inch pipes in steam, vacuum or vapor systems (as in ordinary practice for air lines) and who criticizes 1-inch or $\frac{3}{4}$-inch hot water pipes is, indeed, hard to understand, as in the three first systems the elements combine beautifully to cause the corrosion he professes to fear.

Friction.

The subject of friction "sounds" important, and in theory would seem moderately so, but a consideration of tables, derived from passing given quantity of water, from given height, through various sized pipes, indicates clearly that the degree of increase in "friction" in any two succeeding commercial pipe sizes in descending scale is negligible.

The motive power supplied by use of smaller pipes as used in the Honeywell Method (they lose their heat faster and so create a greater temperature difference between flow and return), abundantly offsets effect of friction.

We have covered these subjects, not because any number of heating contractors are misled by poor reasoning on different subjects, but to re-

move any shadow of doubt and to show our desire to canvass all phases of the subject of Hot Water Heating.

Loss of Head by Friction.

Inside Diameter of Pipe in Inches.

Velocity in Feet Per Second	1 INCH		2 INCH	
	Loss of Head in Feet	Cubic Feet Per Minute	Loss of Head in Feet	Cubic Feet Per Minute
2.0	2.37	.65	1.185	2.62
3.0	4.89	.99	2.44	3.92
4.0	8.20	1.32	4.10	5.23
5.0	12.33	1.65	6.17	6.54
6.0	17.23	1.98	8.61	7.85
7.0	22.89	2.31	11.45	9.16

Velocity in Feet Per Second	3 INCH		4 INCH	
	Loss of Head in Feet	Cubic FeetPer Minute	Loss of Head in Feet	Cubic Feet Per Minute
2.0	.791	5.89	.593	10.4
3.0	1.62	8.83	1.22	15.7
4.0	2.73	11.80	2.05	20.9
5.0	4.11	14.70	3.08	26.2
6.0	5.74	17.70	4.31	31.4
7.0	7.62	20.6	5.72	36.6

Above table from standard authority shows loss of head by friction in each 100 feet in length of different diameters of pipe when discharging the different quantities of water per minute.

Directions for Filling and Emptying Honeywell Hot Water Plants

To fill apparatus, open feed cock when heater is connected with a pressure supply; if not, fill through funnel at tank, taking care to open by-pass around Generator.

In filling the system, see first that all air cocks on radiators are closed; then beginning with lower floor, open air cocks on each radiator, one at a time until radiator is filled. Close air cock as water comes and take next radiator until all are filled, after which let water run until it shows in expansion tank. After heating a short while, vent all radiators by opening air valves as before, admitting whatever water may be necessary to raise to the level of expansion.

If expansion tank has been placed at proper height less difficulty will be experienced in filling and keeping filled.

To Empty.

To empty, open draw off cock at boiler and each air cock, one after another, beginning with the highest radiator. If Generator is by-passed, open valve in by-pass. Drain slowly until expansion tank has been emptied, after which draw off

cock may be opened wide. The draw off cock should be located at the lowest point in the system and if apparatus is properly piped the water will run out of the entire system.

To drain Generator, open draining plug marked '10,' shown in our sketch; *if building is to be left in winter without any fire, Generator should be disconnected.*

Never leave the apparatus full of water in freezing weather when there is no fire. *Never* draw the water off while there is a fire in the boiler unless so timed as to have both run out together. *Never* start a fire until the system is filled with water or at least until water has risen high enough to fill boiler and lower floor radiators

Firing.

Keep the fire pot full of fuel. Most boiler manufacturers put their fuel line half way up firing door. A full fire pot is decidedly the economical and satisfactory way of running any boiler, more especially during cold weather. *Keep a clean fire,* removing ashes from fire pot by shaking grates, or by use of a slice bar through clinker door. Remove ashes from the ash pit regularly. Grates will not stand for any length of time with fire above and heat below.

Economy of fuel is effected by careful attention to the fire and drafts. The time to *attend to a fire is not when the temperature of the house has fallen.* It should be attended to at regular in-

tervals. This attention is best given by automatic temperature regulating devices, which adjust the heater drafts to meet the varying temperature condition in the living rooms. By this means a maximum of comfort is obtained with a minimum of labor and fuel consumption.

At night the fire should be cleaned thoroughly if weather is cold. If weather is mild some ashes should be left on the grates. Put on small amount of fuel and allow fire to burn until coal is well ignited or as some express it, "till the gas is blown off." Then fill fire pot full of fresh coal and arrange the dampers as experiment and acquaintance with each particular job will indicate to be the best way, or permit automatic devices to regulate drafts.

To have efficient heating apparatus, it is of great importance that flue surface be kept free from soot, ashes and incrustation. Clean boiler surface, both under and top side of sections, with tools sent out for that purpose. An incrustation amounting to only ¼ inch may mean as much as 50 per cent addition to your coal bill.

Care of Radiators.

Occasionally it is well to make the rounds of radiators, opening the air cocks to allow the escape of any accumulation of air. Air and water cannot at the same time occupy the same space. A radiator, air-bound across a line extending through top nipple ports, is useless. Keep air

valve open till water runs, but taking any quantity of water from radiator cannot do any good. As soon as water comes, close off air cock. As much water as you take out from air cock has to be replaced by cold water and there is that much needless loss. If radiator refuses to work see that radiator valve is open.

End of Season.

At the end of the heating season it is well to see that the plant is full of water and during the summer allow the water to remain in the system. Same water can be used year after year. If, however, it is considered necessary to change the water, system should be emptied and refilled at once.

It is not necessary to use cistern or rain water, for reasons given on page 96.

Use of Valves.

We strongly recommend the use of the Unique Hot Water Radiator Valve.

When for any reason the Unique Valve is not used, we recommend that a valve that will not shut off absolutely tight be installed. The benefit of such recommendation would often be appreciated by the proprietor, who has had to endure or the steam fitter, who has had to pay for a frozen radiator. Many good types of hot water

valves have what is called an anti-freezing hole, designed to prevent the complete stoppage of water in cold weather.

We recommend that a gate valve making a perfect joint be used in constructing by-pass around Generator, as per our illustrations page 63. If a loosely fitted valve is used, much of the water of expansion will travel by the line of least resistance and will by-pass the Generator.

Number of Gallons in Tanks.

Length or Depth in Feet	Diameter in Inches			
	18	24	30	36
2	26	47	73	105
2½	33	59	90	131
3	40	71	109	157
3½	47	83	127	183
4	54	95	145	209
4½	61	107	163	235
5	68	119	180	261
5½	75	131	200	287
6	82	143	217	313
6½	89	155	235	339
7	96	167	253	365
7½	103	179	271	391
8	110	191	289	417
8½	...	203	307	443
10	...	239	361	521
12	...	287	433	625

Our Proposition for Curing Unsatisfactory Jobs

Attach a Honeywell Heat Generator of suitable size and in a manner as described and illustrated in this book, to the expansion pipe of any unsatisfactory hot water job and try it for 30 days. If at the expiration of this period the architect, heating contractor or owner is not entirely satisfied with the results, the Generator may be disconnected and returned to us and we will cheerfully and promptly refund the purchase price, pay the fitter $3.00 for his time for fitting the Generator and bear all return charges.

List Prices For Plants Containing 2,500 sq. ft. or Less of Radiation

Honeywell Tank-in-Basement equipment consists of a Special Honeywell Heat Generator and a No. 3 Honeywell Syphon Water Regulator, which lists at the following prices:

No. 11 for one-story buildings	$48.00
No. 12 for two-story buildings	52.00
No. 13 for three-story buildings	56.00

Equipment for plants containing more than 2,500 square feet of radiation, or buildings having more than three stories will be furnished upon request.

List Prices for Regular Pattern Honeywell Heat Generators

No. 1 carries up to 1200 square feet of radiation	$25.00
No. 2 carries up to 2500 square feet of radiation	35.00
No. 3 carries up to 4500 square feet of radiation	50.00
No. 4 carries up to 10000 square feet of radiation	65.00

For buildings of any height.

Tank Circulators.

One size only, tapped ¾″ $4.00

Velocity of Flow of Water.

In Feet per Minute, Through Pipes of Various Sizes, for Varying Quantities of Flow

Gals. Per Min.	¾ Inch	1 Inch	1¼ Inch	1½ Inch	2 Inch	2½ Inch	3 Inch	4 Inch
5	218	122½	78½	54½	30½	19½	13½	7⅔
10	436	245	157	109	61	38	27	15⅓
15	653	367½	235½	163½	91½	58½	40½	23
20	872	490	314	218	122	78	54	30⅔
25	1090	612½	392½	272½	152½	97½	67½	38⅓
30	....	735	451	327	183	117	81	46
35	....	857½	549½	381½	213½	136½	94½	53⅔
40	....	980	628	436	244	156	108	61⅓
45	....	1102½	706½	490½	274½	175½	121½	69
50	....	.....	785	545	305	195	135	76⅔
75	....	.....	1177½	817½	457½	292½	202½	115
100	....	.....	.....	1090	610	380	270	153⅓
125	....	.....	.....	.....	762½	487½	337½	191⅔
150	....	.....	.....	.....	915	585	405	230
175	....	.....	.....	.....	1067½	682½	472½	268⅓
200	....	.....	.....	.....	1220	780	540	306⅔

Square Feet of Radiating Surface of Pipe per Lineal Foot

On all lengths over one foot, fractions less than tenths are added to or dropped

Length of Pipe	SIZE OF PIPE											
	¾	1	1¼	1½	2	2½	3	4	5	6	7	8
1............	.275	.346	.434	.494	.622	.753	.916	1.175	1.455	1.739	1.996	2.257
2............	.5	.7	.9	1.	1.2	1.5	1.8	2.4	2.9	3.5	4.	4.5
3............	.8	1.	1.3	1.5	1.9	2.3	2.7	3.5	4.4	5.2	6.	6.8
4............	1.1	1.4	1.7	2.	2.5	3.	3.6	4.7	5.8	7.	8.	9.
5............	1.4	1.7	2.2	2.4	3.1	3.8	4.6	5.8	7.3	7.7	10.	11.3
6............	1.6	2.1	2.6	2.9	3.7	4.5	5.5	7.	8.7	10.5	12.	13.5
7............	1.9	2.4	3.	3.4	4.4	5.3	6.4	8.2	10.2	12.1	14.	15.8
8............	2.2	2.8	3.5	3.9	5.	6.	7.3	9.4	11.6	13.9	16.	18.
9............	2.5	3.1	3.9	4.4	5.6	6.8	8.2	10.6	13.1	15.7	18.	20.3
10............	2.7	3.5	4.3	4.9	6.2	7.5	9.1	11.8	14.6	17.4	20.	22.6
11............	3.	3.8	4.8	5.4	6.8	8.3	10.	12.9	16.	19.1	22.	24.9
12............	3.3	4.1	5.2	5.9	7.5	9.	11.	14.1	17.4	20.9	24.	27.1
13............	3.6	4.5	5.6	6.4	8.1	9.8	11.9	15.3	18.9	22.6	26.	29.4
14............	3.8	4.8	6.1	6.9	8.7	10.5	12.8	16.5	20.3	24.3	28.	31.6
15............	4.1	5.2	6.5	7.4	9.3	11.3	13.7	17.6	21.8	26.1	30.	33.9
16............	4.4	5.5	6.9	7.9	10.	12.	14.6	18.8	23.2	27.8	32.	36.1
17............	4.7	5.9	7.4	8.4	10.6	12.8	15.5	20.	24.7	29.5	34.	38.4
18............	5.	6.2	7.8	8.9	11.2	13.5	16.5	21.2	26.2	31.3	36.	40.6
19............	5.2	6.6	8.3	9.4	11.8	14.3	17.4	22.3	27.6	33.1	38.	42.9

Square Feet of Radiating Surface of Pipe per Lineal Foot—Continued.

20	5.5	6.9	8.7	9.9	12.5	15.	18.3	23.5	29.1	34.8	40.	45.2
21	5.8	7.3	9.1	10.4	13.	15.8	19.2	24.7	30.5	36.5	42.	47.4
22	6.	7.6	9.6	10.9	13.7	16.5	20.2	25.9	32.	38.3	44.	49.7
23	6.3	8.	10.	11.3	14.3	17.3	21.1	27.	33.5	40.	46.	52.
24	6.6	8.3	10.4	11.9	14.9	18.	22.	28.2	34.9	41.7	48.	54.2
25	6.9	8.6	10.9	12.3	15.6	18.8	22.9	29.3	36.3	43.5	50.	56.4
26	7.1	9.	11.3	12.8	16.2	19.5	23.8	30.5	37.8	45.2	52.	58.6
27	7.4	9.4	11.7	13.3	16.8	20.3	24.7	31.7	39.3	47.	54.	61.
28	7.7	9.7	12.2	13.8	17.4	21.	25.6	32.9	40.7	48.7	56.	63.2
29	8.	10.	12.6	14.3	18.	21.8	26.6	34.1	42.2	50.4	58.	65.5
30	8.3	10.4	13.	14.8	18.7	22.5	27.5	35.3	43.6	52.1	60.	67.7
31	8.5	10.7	13.5	15.3	19.3	23.3	28.4	36.4	45.1	53.9	62.	70.
32	8.8	11.1	13.9	15.8	19.9	24.1	29.3	37.6	46.5	55.6	64.	72.2
33	9.1	11.4	14.3	16.3	20.5	24.8	30.2	38.8	48.	57.4	66.	74.4
34	9.4	11.7	14.7	16.8	21.2	25.6	31.1	40.	49.5	59.1	68.	76.7
35	9.6	12.1	15.2	17.3	21.8	26.3	32.	41.1	50.9	60.8	70.	79.
36	9.9	12.5	15.6	17.8	22.4	27.	33.	42.3	52.4	62.6	72.	81.3
37	10.2	12.8	16.1	18.3	23.	27.8	33.9	43.5	53.8	64.3	74.	83.5
38	10.5	13.2	16.5	18.8	23.7	28.5	34.8	44.6	55.2	66.	76.	85.8
39	10.7	13.5	16.9	19.3	24.3	29.3	35.7	45.8	56.7	67.8	78.	88.
40	11.	13.8	17.4	19.8	24.9	30.1	36.6	47.	58.2	69.5	80.	90.2
41	11.3	14.2	17.8	20.3	25.5	30.8	37.6	48.2	59.6	71.3	82.	92.5
42	11.5	14.5	18.2	20.8	26.1	31.6	38.5	49.4	61.1	73.	84.	94.8
43	11.8	14.9	18.7	21.3	26.8	32.3	39.4	50.6	62.5	74.8	86.	97.
44	12.1	15.2	19.1	21.8	27.4	33.1	40.3	51.7	64.	76.5	88.	99.3
45	12.4	15.6	19.5	22.2	28.	33.8	41.2	52.9	65.5	78.2	90.	101.6
46	12.7	15.9	20.	22.7	28.6	34.6	42.2	54.	67.	80.	92.	103.8
47	12.9	16.3	20.4	23.2	29.2	35.3	43.	55.2	68.4	81.7	94.	106.
48	13.2	16.6	20.8	23.7	29.9	36.1	43.9	56.4	69.8	83.5	96.	108.4
49	13.5	17.	21.3	24.2	30.5	36.8	44.8	57.6	71.2	85.1	98.	110.5
50	13.8	17.3	21.7	24.7	31.1	37.6	45.8	58.7	72.7	87.	100.	112.8

NOTE—Above information is quoted from standard authorities. Not guaranteed.

Areas of Circles

Size	Area	Size	Area
1/8	0.0123	10	78.54
1/4	0.0491	1/2	86.59
3/8	0.1104	11	95.03
1/2	0.1963	1/2	103.86
5/8	0.3067	12	113.09
3/4	0.4417	1/2	122.71
7/8	0.6013	13	132.73
1	0.7854	1/2	143.13
1/8	0.9940	14	153.93
1/4	1.227	1/2	165.13
3/8	1.484	15	176.71
1/2	1.767	1/2	188.69
5/8	2.073	16	201.06
3/4	2.405	1/2	213.82
7/8	2.761	17	226.98
2	3.141	1/2	240.52
1/4	3.976	18	254.46
1/2	4.908	1/2	268.80
3/4	5.939	19	283.52
3	7.068	1/2	298.64
1/4	8.295	20	314.16
1/2	9.621	1/2	330.06
3/4	11.044	21	346.36
4	12.566	1/2	363.05
1/2	15.904	22	380.13
5	19.635	1/2	397.60
1/2	23.758	23	415.47
6	28.274	1/2	433.73
1/2	33.183	24	452.39
7	38.484	1/2	471.43
1/2	44.178	25	490.87
8	50.265	26	530.93
1/2	56.745	27	572.55
9	63.617	28	615.75
1/2	70.882	29	660.52

To find the diameter of a circle when circumference is given multiply the given circumference by .3183.

Area of Circles—Continued

Size	Area	Size	Area
30	706.86	65	3318.3
31	754.76	66	3421.2
32	804.24	67	3525.6
33	855.30	68	3631.6
34	907.92	69	3739.2
35	962.11	70	3848.4
36	1017.8	71	3959.2
37	1075.2	72	4071.5
38	1134.1	73	4185.3
39	1194.5	74	4300.8
40	1256.6	75	4417.8
41	1320.2	76	4536.4
42	1385.4	77	4656.0
43	1452.2	78	4778.3
44	1520.5	79	4901.6
45	1590.4	80	5026.5
46	1661.9	81	5153.0
47	1734.9	82	5281.0
48	1809.5	83	5410.6
49	1885.7	84	5541.7
50	1963.5	85	5674.5
51	2042.8	86	5808.8
52	2123.7	87	5944.6
53	2206.1	88	6082.1
54	2290.2	89	6221.1
55	2375.8	90	6361.7
56	2463.0	91	6503.8
57	2551.7	92	6647.6
58	2642.0	93	6792.9
59	2733.9	94	6939.7
60	2827.4	95	7088.2
61	2922.4	96	7238.2
62	3019.0	97	7389.8
63	3117.2	98	7542.9
64	3216.9	99	7697.7

To find the diameter of a circle when circumference is given, multiply the given circumference by .3183

Circumference of Circles

Size	Circumference	Size	Circumference
1/8	.3927	10	31.416
1/4	.7854	1/2	32.987
3/8	1.1781	11	34.558
1/2	1.5708	1/2	36.128
5/8	1.9635	12	37.699
3/4	2.3562	1/2	39.270
7/8	2.7489	13	40.841
1	3.1416	1/2	42.412
1/8	3.5343	14	43.982
1/4	3.9270	1/2	45.553
3/8	4.3197	15	47.124
1/2	4.7124	1/2	48.695
5/8	5.1051	16	50.265
3/4	5.4978	1/2	51.836
7/8	5.8905	17	53.407
2	6.2832	1/2	54.978
1/4	7.0686	18	56.549
1/2	7.8540	1/2	58.119
3/4	8.6394	19	59.690
3	9.4248	1/2	61.261
1/4	10.210	20	62.832
1/2	10.996	1/2	64.403
3/4	11.781	21	65.973
4	12.566	1/2	67.544
1/2	14.137	22	69.115
5	15.708	1/2	70.686
1/2	17.279	23	72.257
6	18.850	1/2	73.827
1/2	20.420	24	75.398
7	21.991	1/2	76.969
1/2	23.562	25	78.540
8	25.133	26	81.681
1/2	26.704	27	84.823
9	28.274	28	87.965
1/2	29.845	29	91.106

To find the circumference of a circle when diameter is given, multiply the given diameter by 3.1416.

Circumference of Circles—Continued

Size	Circumference	Size	Circumference
30	94.248	65	204.204
31	97.389	66	207.345
32	100.531	67	210.487
33	103.673	68	213.628
34	106.814	69	216.770
35	109.956	70	219.911
36	113.097	71	223.053
37	116.239	72	226.195
38	119.381	73	229.336
39	122.522	74	232.478
40	125.664	75	235.619
41	128.805	76	238.761
42	131.947	77	241.903
43	135.088	78	245.044
44	138.230	79	248.186
45	141.372	80	251.327
46	144.513	81	254.469
47	147.655	82	257.611
48	150.796	83	260.752
49	153.938	84	263.894
50	157.080	85	267.035
51	160.221	86	270.177
52	163.363	87	273.319
53	166.504	88	276.460
54	169.646	89	279.602
55	172.788	90	282.743
56	175.929	91	285.885
57	179.071	92	289.027
58	182.212	93	292.168
59	185.354	94	295.310
60	188.496	95	298.451
61	191.637	96	301.593
62	194.779	97	304.734
63	197.920	98	307.876
64	201.062	99	311.018

To find the circumference of a circle when diameter is given multiply the given diameter by 3.1416.

Climatic Temperatures

Lowest and Average Degrees in the U. S.

(Compiled from U. S. Weather Bureau Records)

State	City	Lowest	*Av.
Alabama	Mobile	- 1	57.7
	Montgomery	- 5	56.1
Arizona	Flagstaff	-17	34.8
	Phoenix	12	58.9
Arkansas	Fort Smith	-15	49.5
	Little Rock	-12	52.0
California	San Diego	32	57.2
	Independence	10	48.7
Colorado	Denver	-29	38.4
	Grand Jct.	-16	39.2
Connecticut	Hartford	-14	36.3
District of Columbia	Washington	-15	42.9
Florida	Jupiter	24	69.8
	Jacksonville	10	60.9
Georgia	Savannah	8	57.2
	Atlanta	- 8	51.4
Idaho	Boise	-28	39.6
	Lewiston	-18	42.5
Illinois	Chicago	-23	35.9
	Springfield	-22	39.0
Indiana	Indianapolis	-25	40.4
	Evansville	-15	44.1
Iowa	Sioux City	- 3	32.1
	Keokuk	-24	37.6
Kansas	Ft. Dodge	-26	....
	Wichita	-22	42.9
Kentucky	Louisville	-20	45.0
Louisiana	New Orleans	7	60.5
	Shreveport	- 5	55.7
Maine	Eastport	-21	31.1
	Portland	-17	33.5
Maryland	Baltimore	- 7	43.3
Massachusetts	Boston	-13	37.2
Michigan	Alpena	-27	29.1
	Detroit	-24	35.3
Minnesota	Duluth	-41	25.5
	Minneapolis	-33	28.4
Mississippi	Meridian	- 6	53.9
	Vicksburg	- 1	56.0
Missouri	Springfield	-29	43.0
	Hannibal	-20	39.7
Montana	Havre	-55	27.7
	Helena	-42	30.9

*October 1st to May 1st. All stated in Fahrenheit.

Climatic Temperatures

Lowest and Average Degrees in the U. S.

(Compiled from U. S. Weather Bureau Records)

State	City	Lowest	*Av.
Nebraska	North Platte	–35	34.6
	Lincoln	–26	35.8
Nevada	Carson City	–22	....
	Winnemucca	–28	37.9
New Hampshire	Concord		33.1
New Jersey	Atlantic City	– 7	41.6
New York	Binghamton	–26	34.1
	New York City	– 6	40.1
New Mexico	Roswell	–18	48.9
	Santa Fe	–13	38.0
North Carolina	Hatteras	8	53.3
	Charlotte	– 5	49.8
North Dakota	Devil's Lake	–51	18.9
	Bismarck	–44	23.5
Ohio	Toledo	–16	36.8
	Columbus	–20	39.8
Oklahoma	Oklahoma City	–17	47.1
Oregon	Baker City	–20	34.1
	Portland	– 2	45.4
Pennsylvania	Pittsburgh	–20	40.8
	Philadelphia	– 6	41.8
Rhode Island	Providence	–12	37.5
	Block Island	– 4	39.7
South Carolina	Charleston	7	56.9
	Columbia	– 2	53.5
South Dakota	Huron	–43	25.9
	Yankton	–32	31.2
Tennessee	Knoxville	–16	47.0
	Memphis	– 9	50.7
Texas	Corpus Christi	11	62.7
	Fort Worth	– 8	49.5
Utah	Salt Lake City	–20	39.7
Vermont	Northfield	–32	27.8
Virginia	Cape Henry	5	48.6
	Lynchburg	– 6	45.2
Washington	Seattle	12	44.3
	Spokane	–30	37.0
West Virginia	Parkersburg	–27	41.9
	Elkins	–21	38.8
Wisconsin	La Crosse	–43	31.2
	Milwaukee	–25	32.4
Wyoming	Cheyenne	–38	33.7
	Landor	–36	29.0

***October 1st to May 1st. All stated in Fahrenheit.**

Table of Altitudes and Boiling Point of Water

LOCALITY	Elevation Above Sea Level, ft.	Boiling Point of Pure Water, deg. F.
Atlanta, Ga.	1,000	210.0
Buffalo, N. Y.	600	210.8
Butte, Mont.	5,700	201.1
Carson, Nev.	4,660	203.0
Chattanooga, Tenn.	674	210.6
Cheyenne, Wyo.	6,000	200.5
Chicago, Ill.	600	210.8
Cincinnati, Ohio	500	211.0
Cleveland, Ohio	642	210.7
Colorado Springs, Colo.	5,982	200.5
Dallas, Texas	425	211.1
Denver, Colo.	5,279	201.9
Detroit, Mich.	600	210.8
Helena, Mont.	4,000	204.3
Knoxville, Tenn.	933	210.1
Leadville, Colo.	10,190	192.9
Missoula, Mont.	3,200	205.8
Nashville, Tenn.	450	211.1
Ogden, Utah	4,300	203.7
Pike's Peak, Colo.	14,108	185.9
Provo, Utah	4,512	203.3
Pueblo, Colo.	4,660	203.0
Rochester, N. Y.	531	210.9
St. Cloud, Minn.	1,020	210.0
St. Louis, Mo.	450	211.1
St. Paul, Minn.	750	210.5
Salt Lake City, Utah	4,300	203.7
San Antonio, Tex.	675	210.6
Saranac Lake, N. Y.	1,574	208.9
Spokane, Wash.	1,900	208.3

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